The Canadian Precipitation Analysis (CaPA): A seamless precipitation analysis for the Great Lakes (and elsewhere in North America)

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Recherche en prévision numérique environnementale

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Environment Canada

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Meteorological Service of Canada

Environment Canada

20th US - Canada Great Lakes Operational Meteorology Workshop

Chicago, 14 – 16 mars 2012

Outline

Focus of this presentation

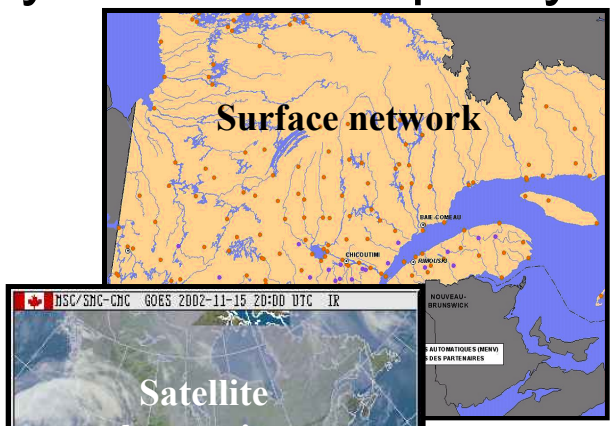
- CaPA objectives, methodology and operational configuration
- Web sites for product dissemination
- Comparison of CaPA with other products (MPE, CPC, USACE)
- Impact of overlake evaporation parameterization on CaPA
- Work in progress

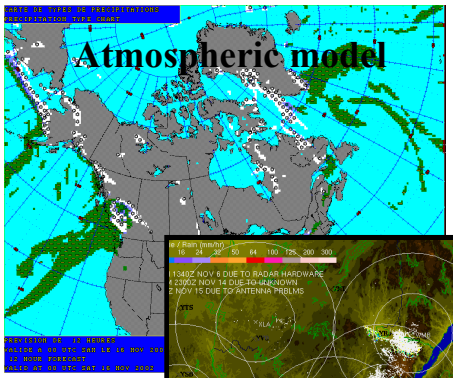
Items left out for lack of time (feel free to ask questions)

- Assimilation of solid precipitation observations
- Objective scores obtained using cross-validation procedure

CaPA objectives and methodology

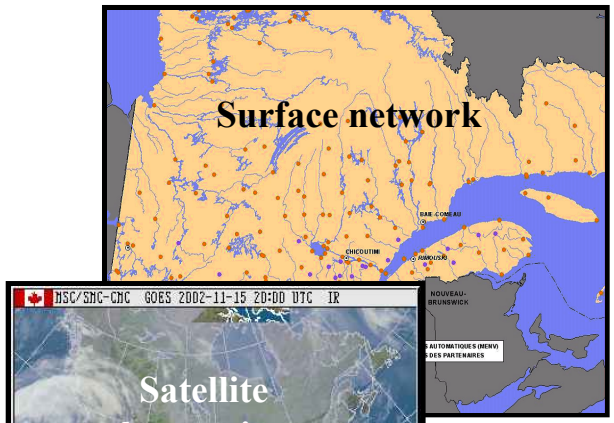
- Near real-time precipitation estimation
- Merge different sources of information on precipitation
- Use background field from the GEM NWP model due to low network density in most of Canada
- Optimal interpolation technique (aka residual kriging)
- Fully automated quality control algorithm

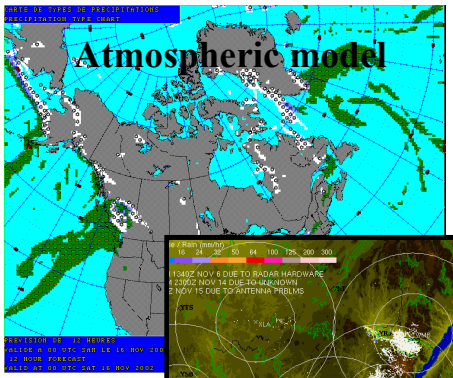




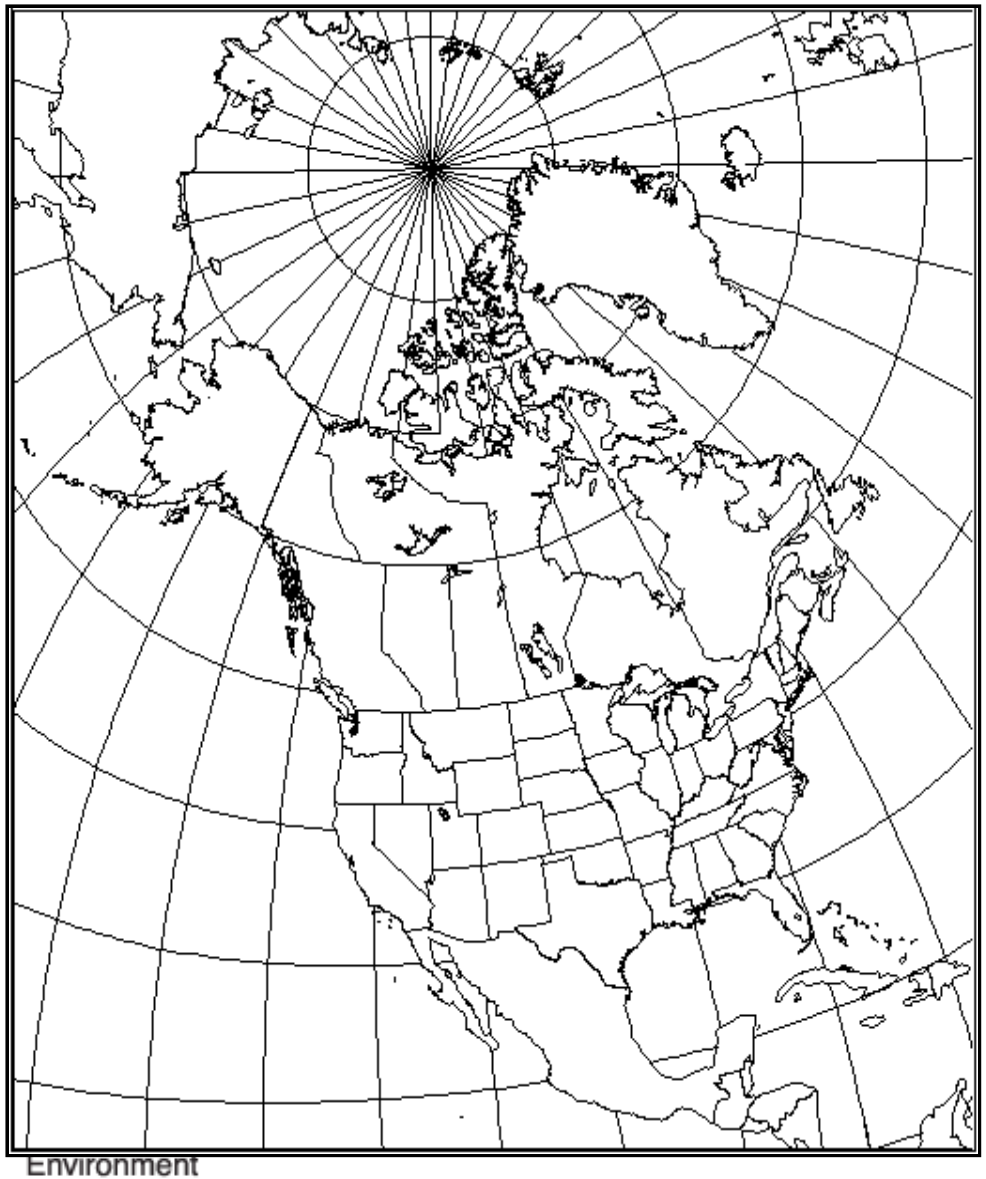
CaPA operational configuration

- Assimilates only gauges
  - radar and satellite assimilated in experimental version
- Background field: GEM RDPS 15 km, 6h-12h lead time
- 6h accumulations valid at 00, 06, 12 and 18 UTC
- 24h accumulation valid at 12 UTC
- Confidence index provided (based on kriging variance)

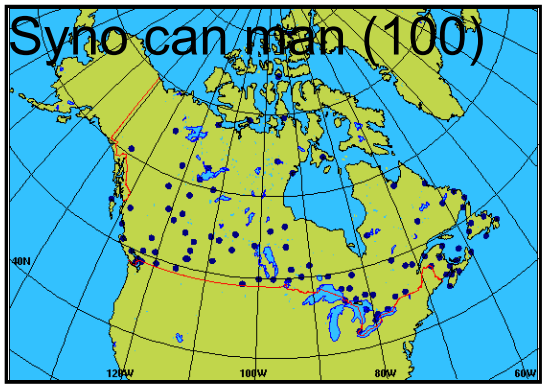


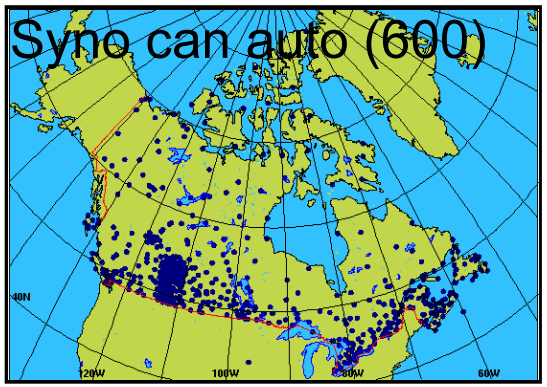


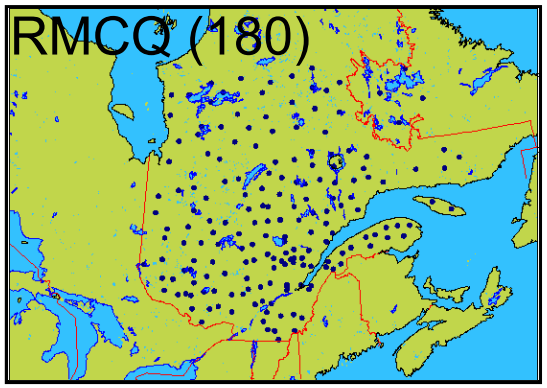
CaPA domain

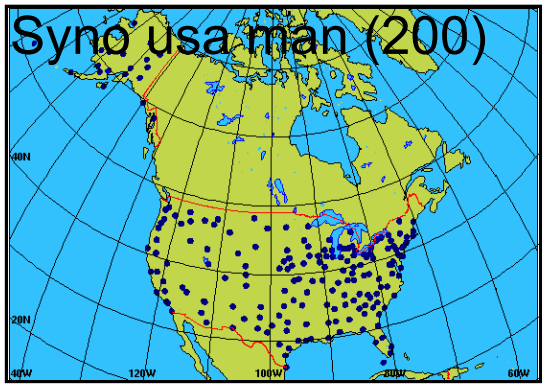


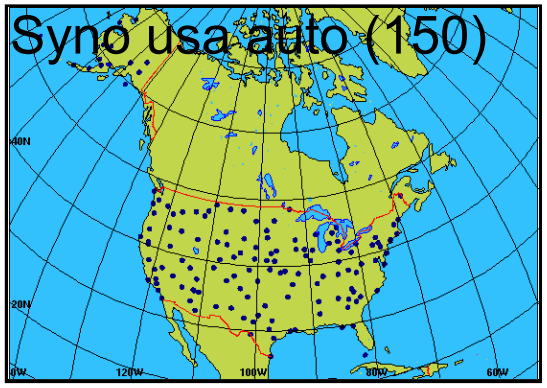
Surface networks assimilated

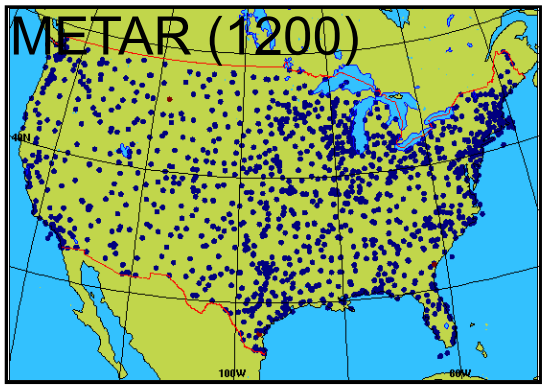


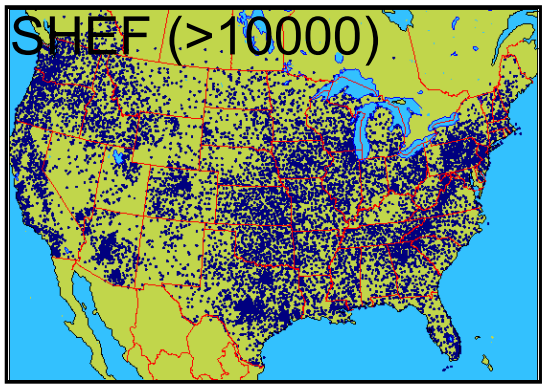












(24h analysis only)

Operational website
http://www.weather.gc.ca/analysis/

Environment Canada | Environnement Canada | Canada

Weatheroffice
www.weatheroffice.gc.ca

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Proactive Disclosure

Operational Analysis Charts

Surface Analysis: MSLP

Hr	Preliminary (Canadian coverage)		Complete (Northern Hemispheric coverage)	
	2640x2100	1320x1050	1791x1531	895X765
00z	200k	115k	165k	90k
06z	200k	110k	165k	90k
12z	200k	110k	165k	90k
18z	200k	110k	165k	90k

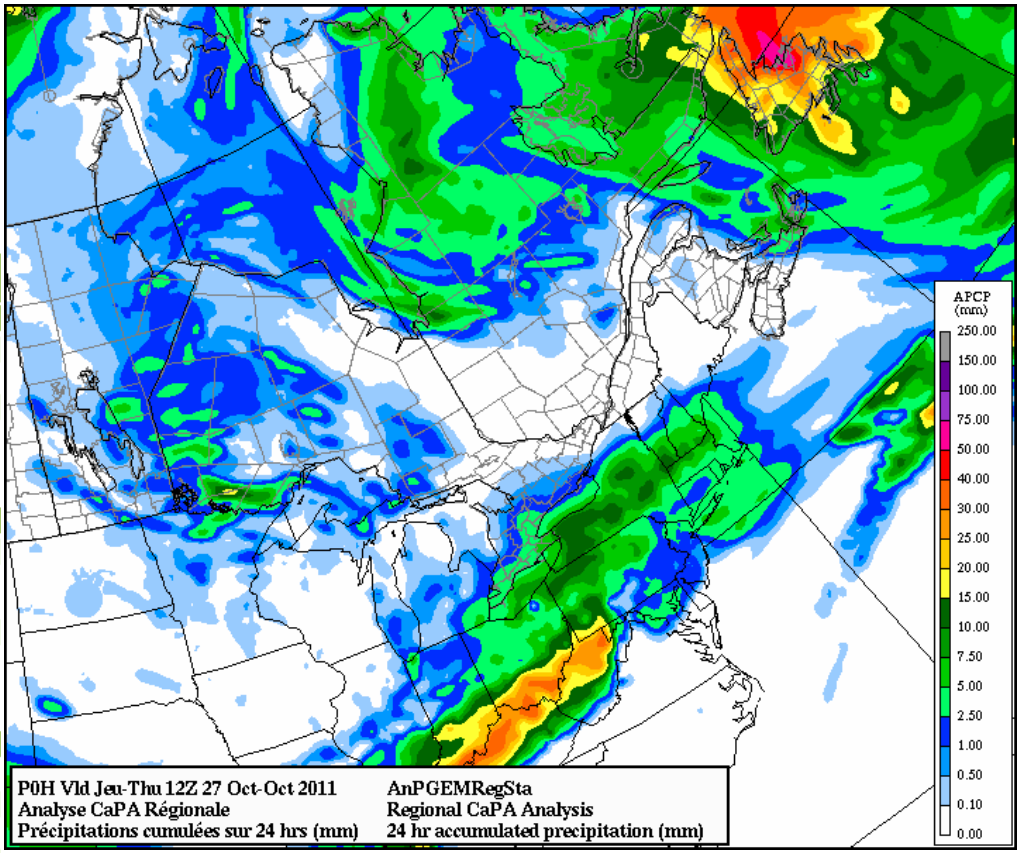
Surface Analysis : Snow, Ice, SST

	1213x894	2425x1787
Snow Depth	90k	170k
Sea Surface Temperature	90k	170k
Sea Ice Cover	90k	170k

Surface Analysis: APCP
Regional Deterministic Precipitation Analysis (RDPA)(1)

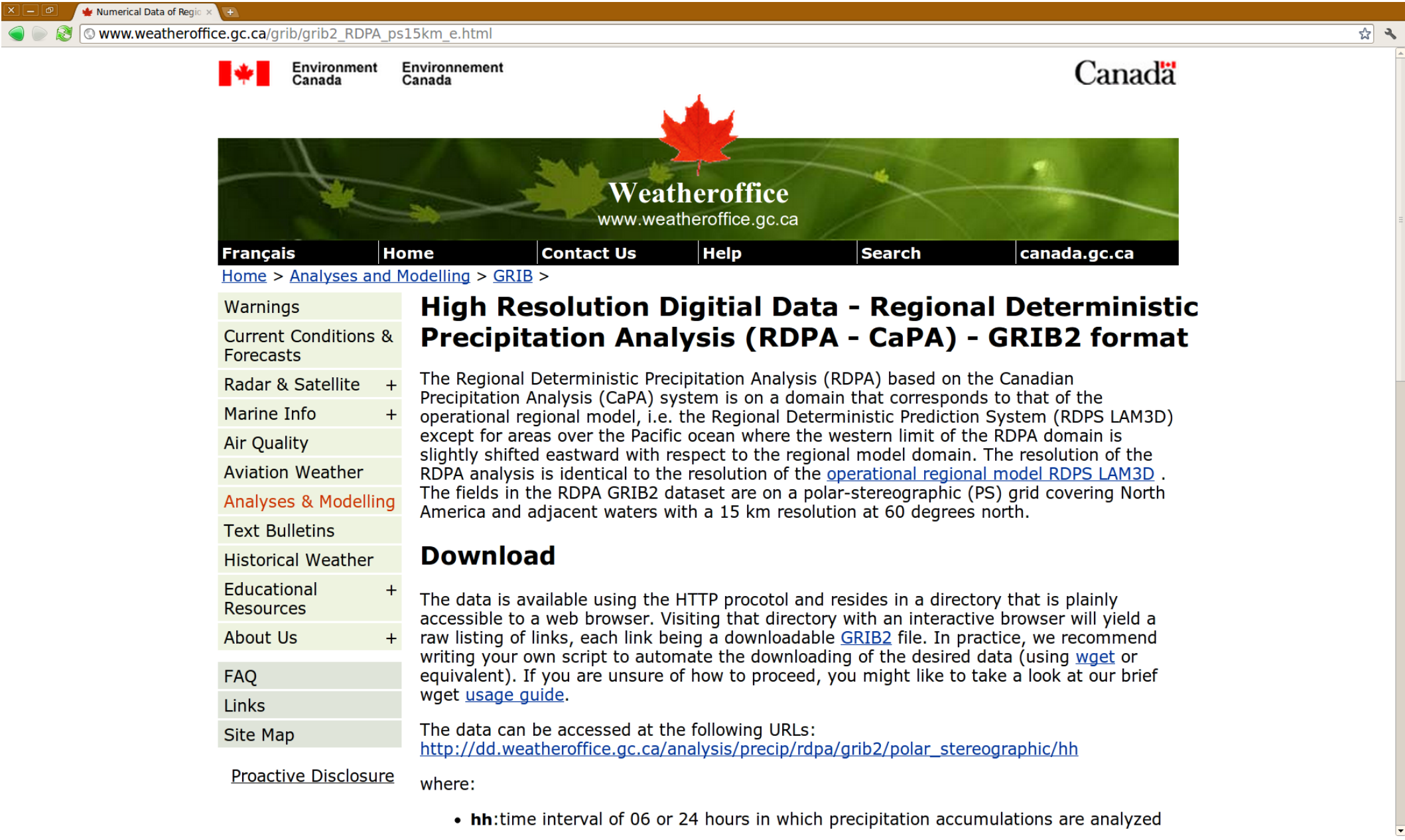
Hr	Region	6hr accumulation	24hr accumulation
00Z	Canada	20111027	
	Eastern Canada	20111027	
	Western Canada	20111027	
06Z	Canada	20111027	
	Eastern Canada	20111027	
	Western Canada	20111027	
12Z	Canada	20111027	20111027
	Eastern Canada	20111027	20111027
	Western Canada	20111027	20111027
18Z	Canada	20111027	
	Eastern Canada	20111027	
	Western Canada	20111027	

(1): Based on the CaPA system

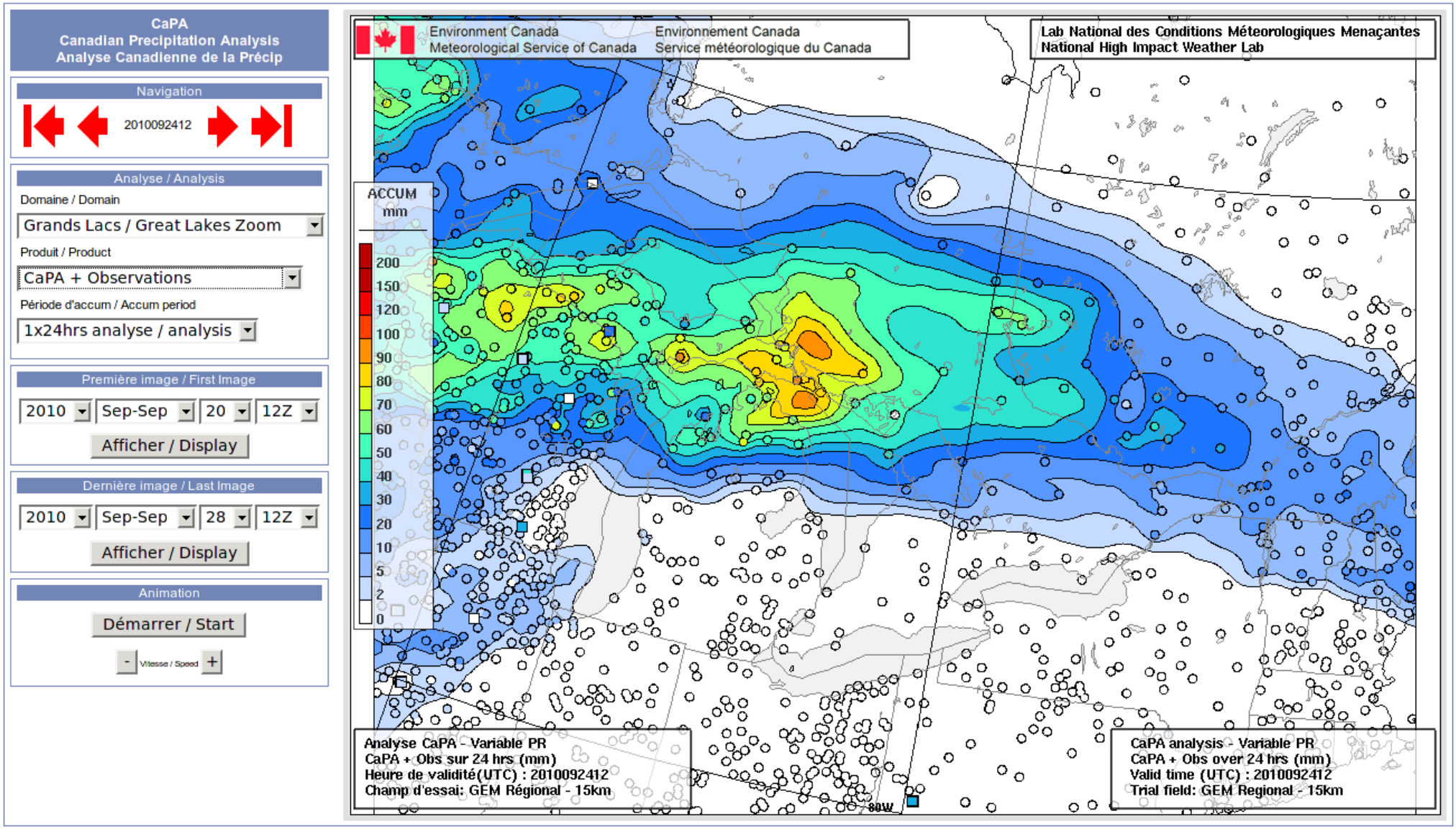


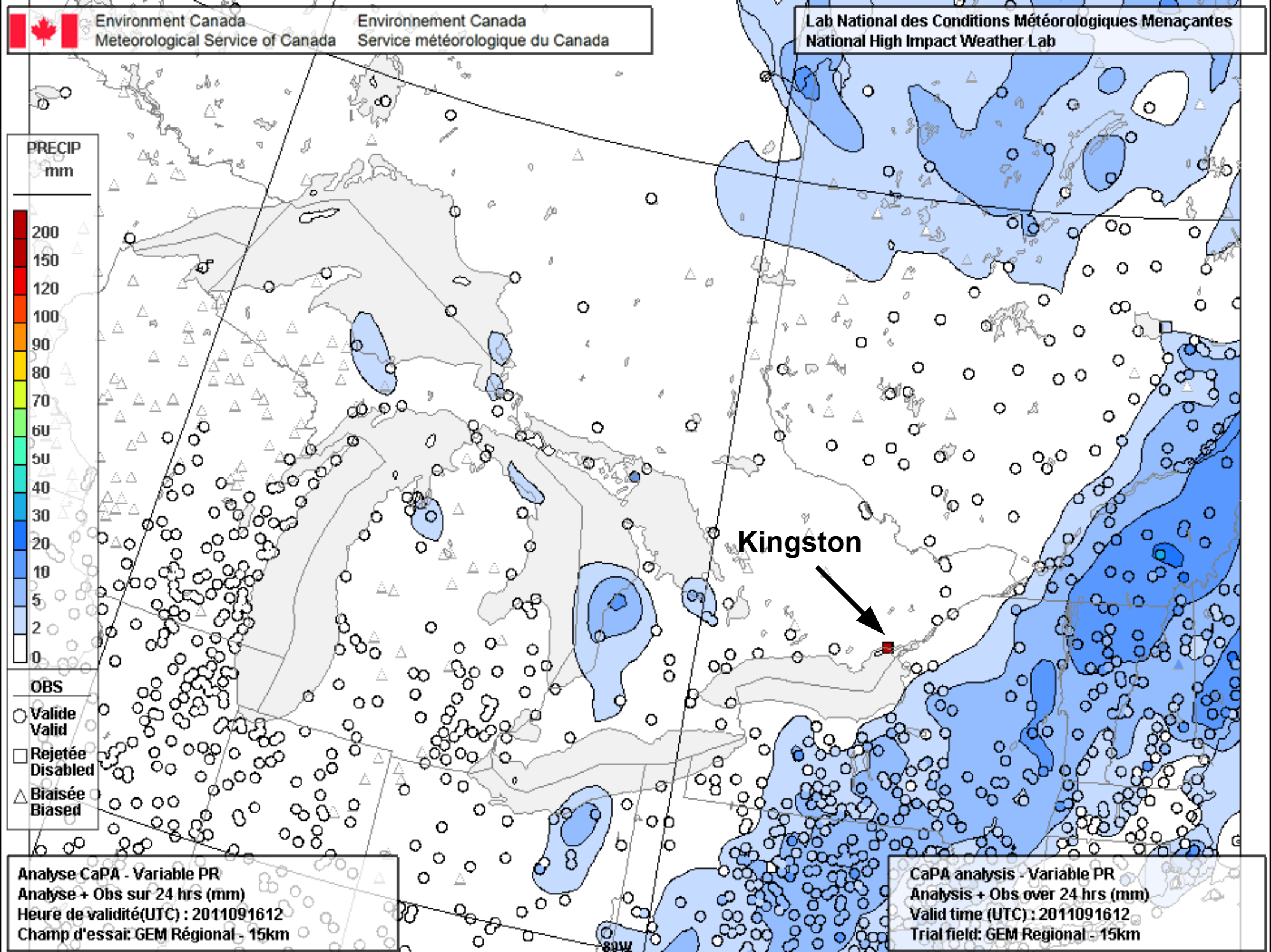
Datamart

http://www.weatheroffice.gc.ca/grib



Experimental web site
http://loki.qc.ec.gc.ca/DAI/CaPA




Environment Canada
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Environnement Canada
Service météorologique du Canada
Lab National des Conditions Météorologiques Menaçantes
National High Impact Weather Lab
PRECIP
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120
100
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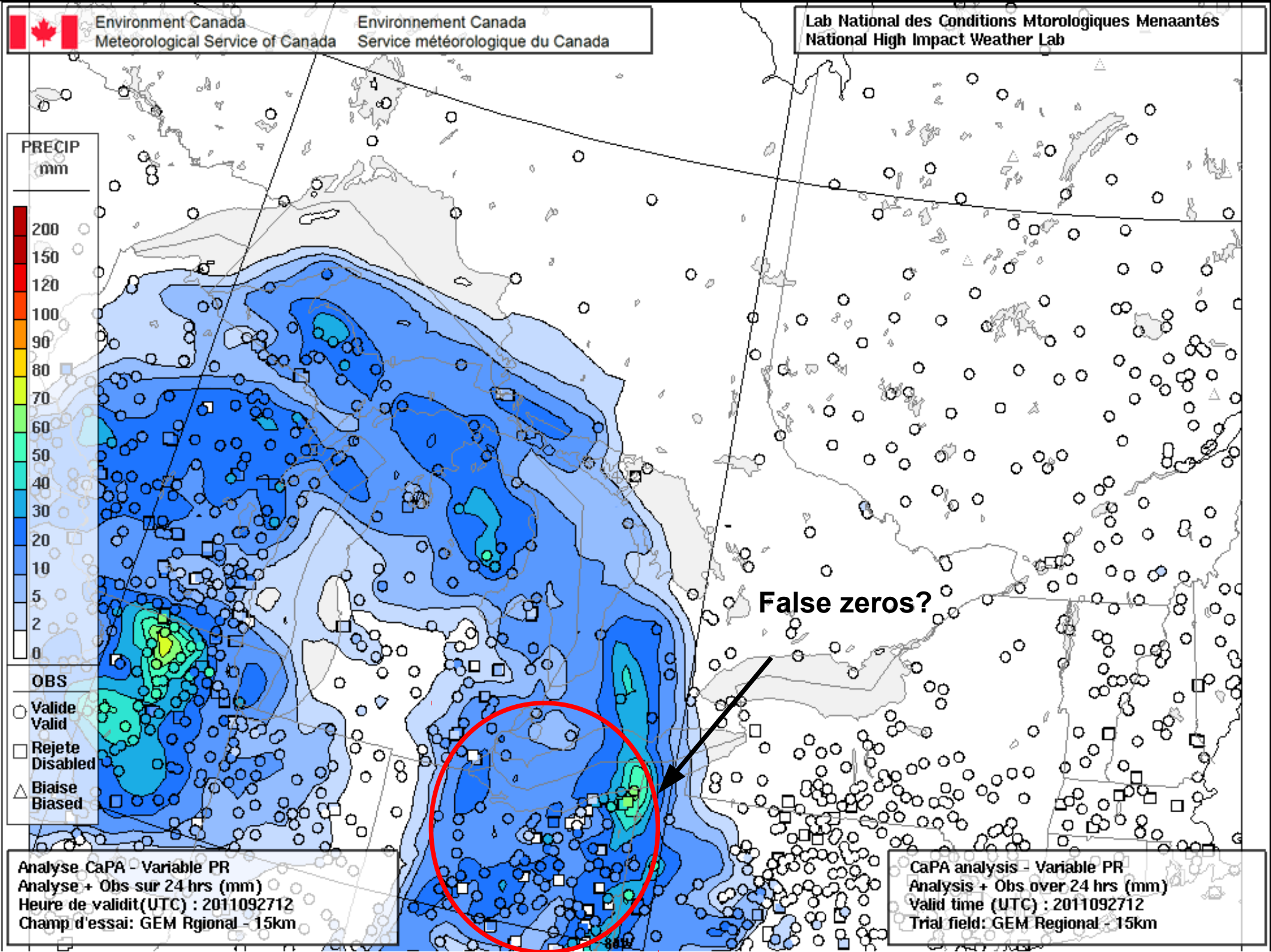
10
5
2
0
OBS
Valide
Valid
Rejetée
Disabled
Biaisée
Biased
Kingston
Analyse CaPA - Variable PR
Analyse + Obs sur 24 hrs (mm)
Heure de validité(UTC) : 2011091612
Champ d'essai: GEM Régional - 15km
CaPA analysis - Variable PR
Analysis + Obs over 24 hrs (mm)
Valid time (UTC) : 2011091612
Trial field: GEM Regional - 15km
89W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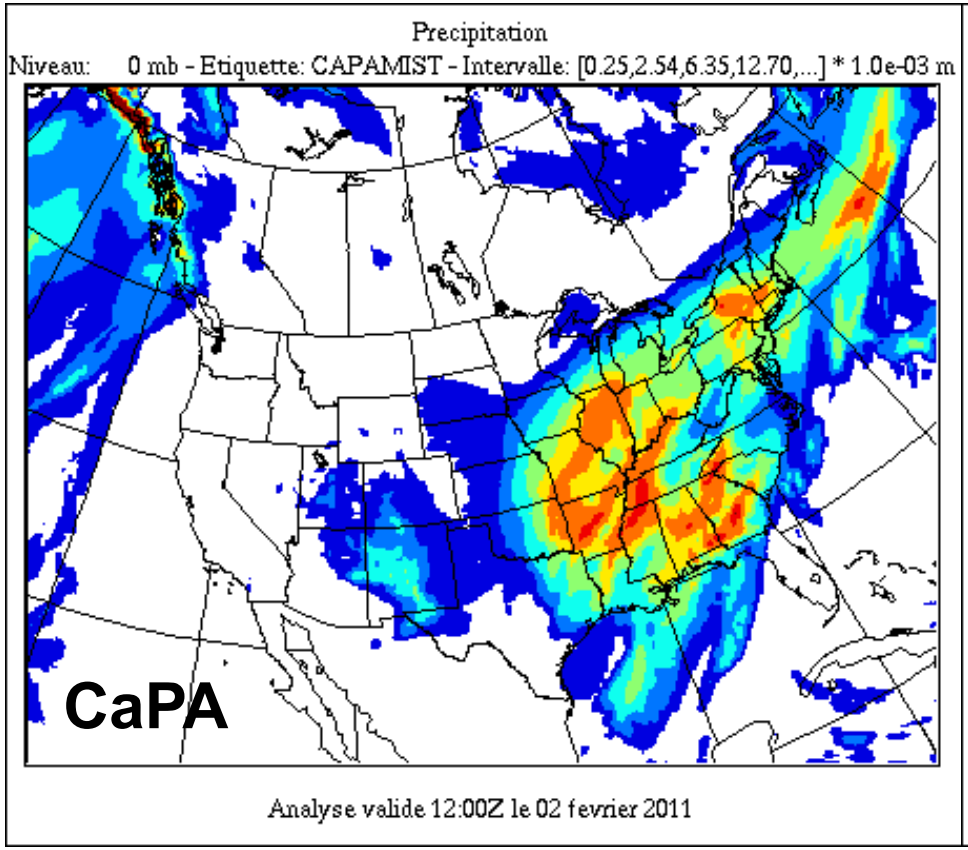
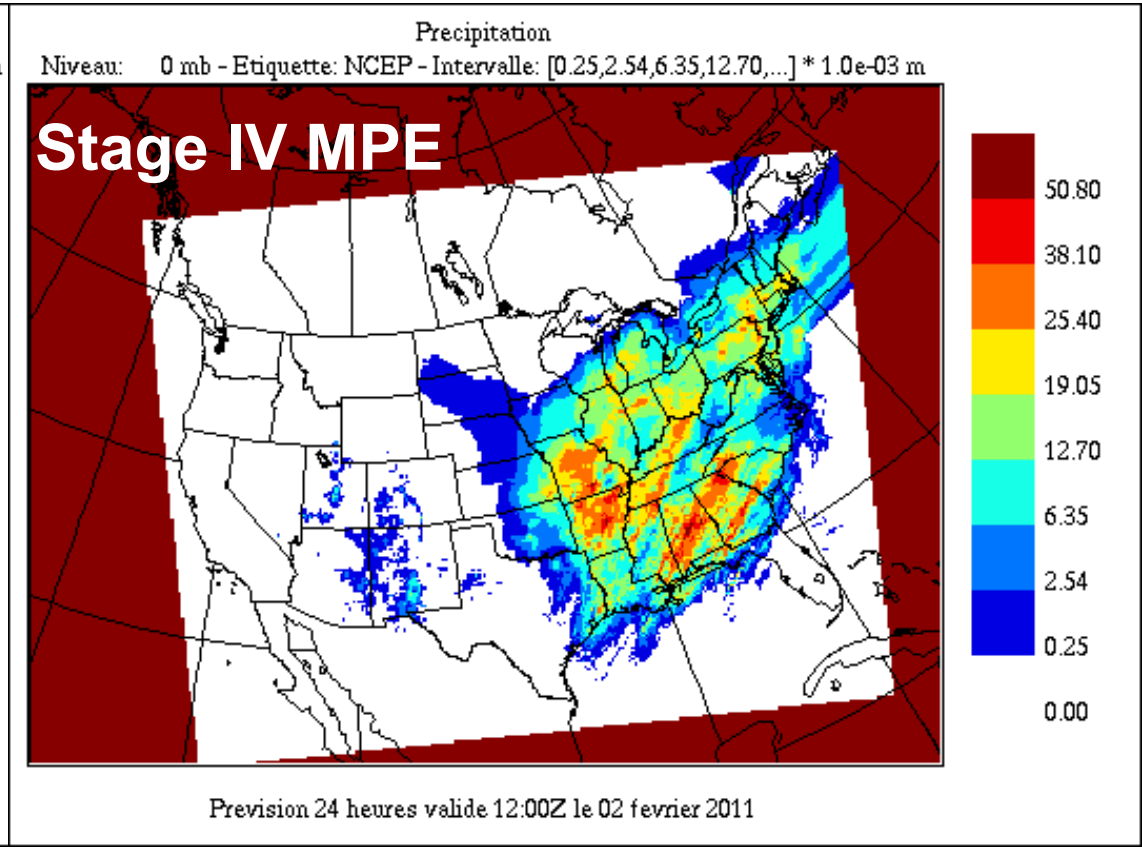
Champ d'essai: GEM Rgional - 15km
CaPA analysis - Variable PR
Analysis + Obs over 24 hrs (mm)
Valid time (UTC) : 2011092712
Trial field: GEM Regional - 15km

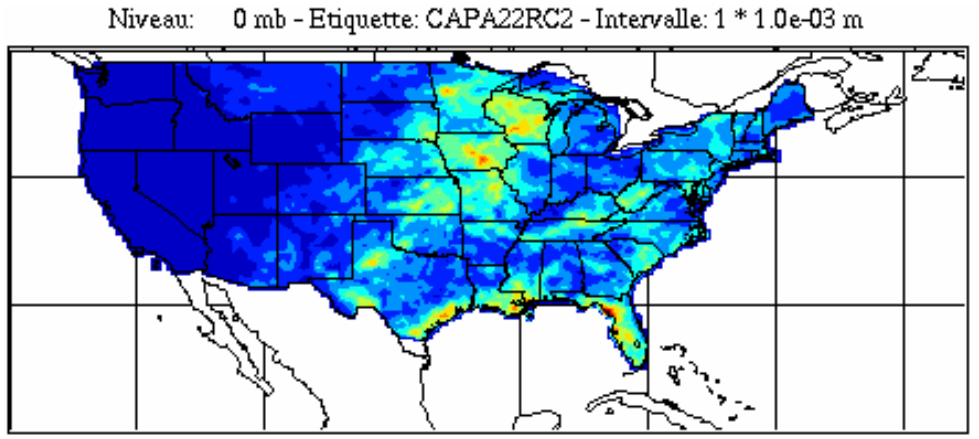
Groundhog day storm
24h accum valid 2011-02-02@12Z



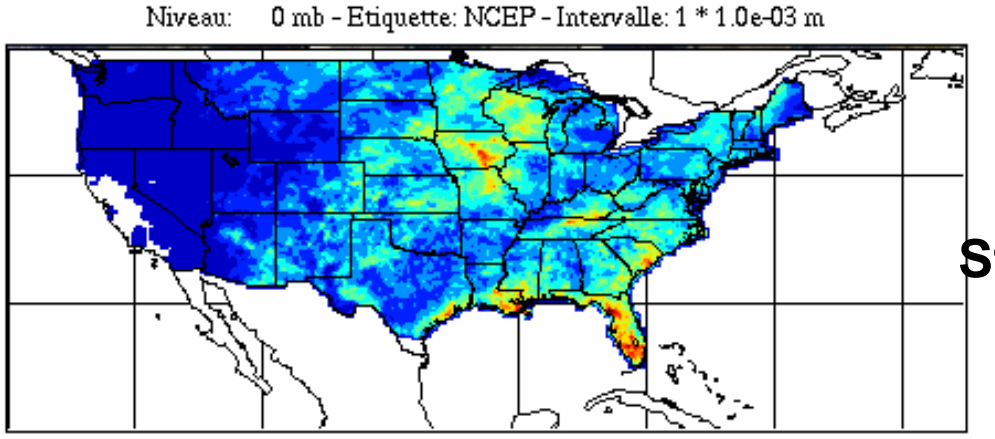


Summer 2010: CaPA vs MPE and CPC

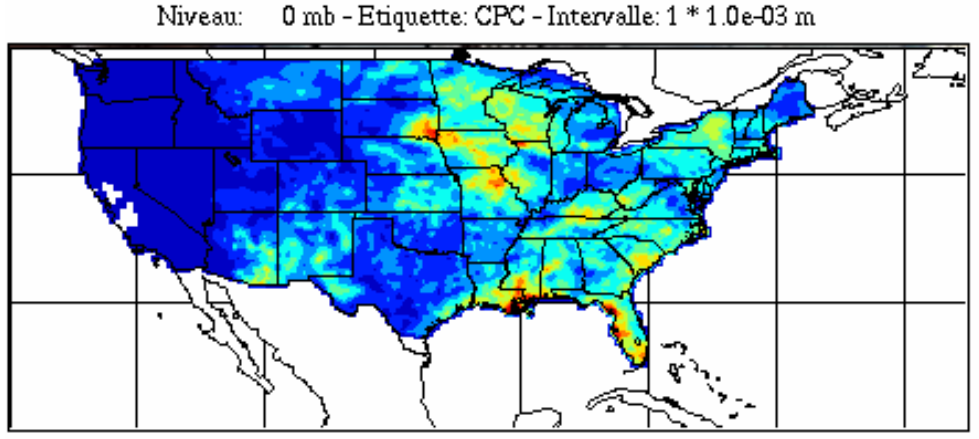
ρ	CaPA	MPE	CPC
CaPA	1	0.93	0.93
MPE	0.93	1	0.92
CPC	0.93	0.92	1



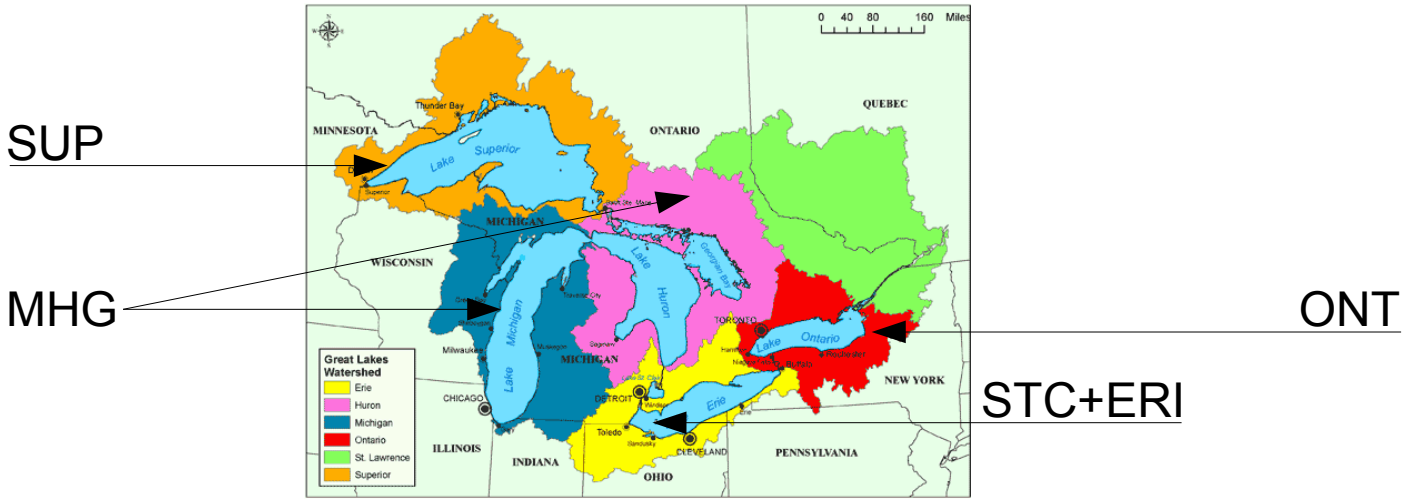
CaPA



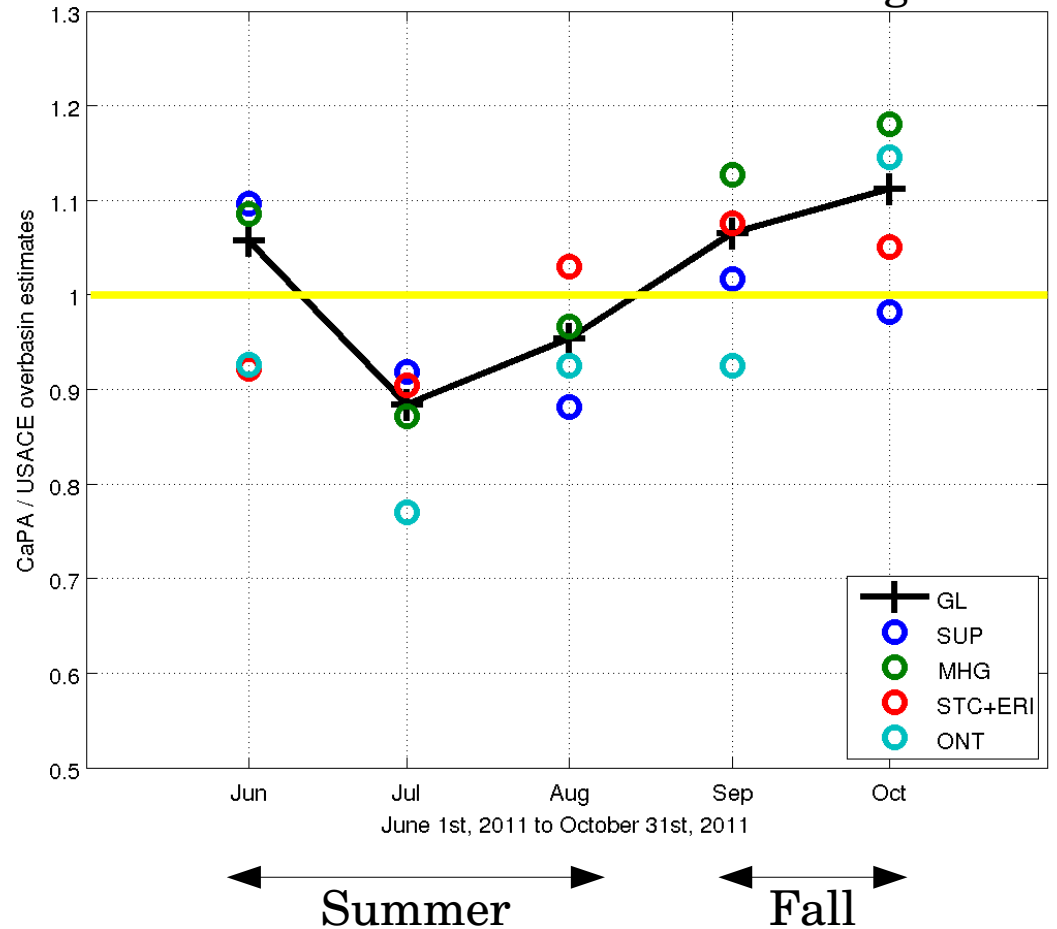
Stage IV MPE



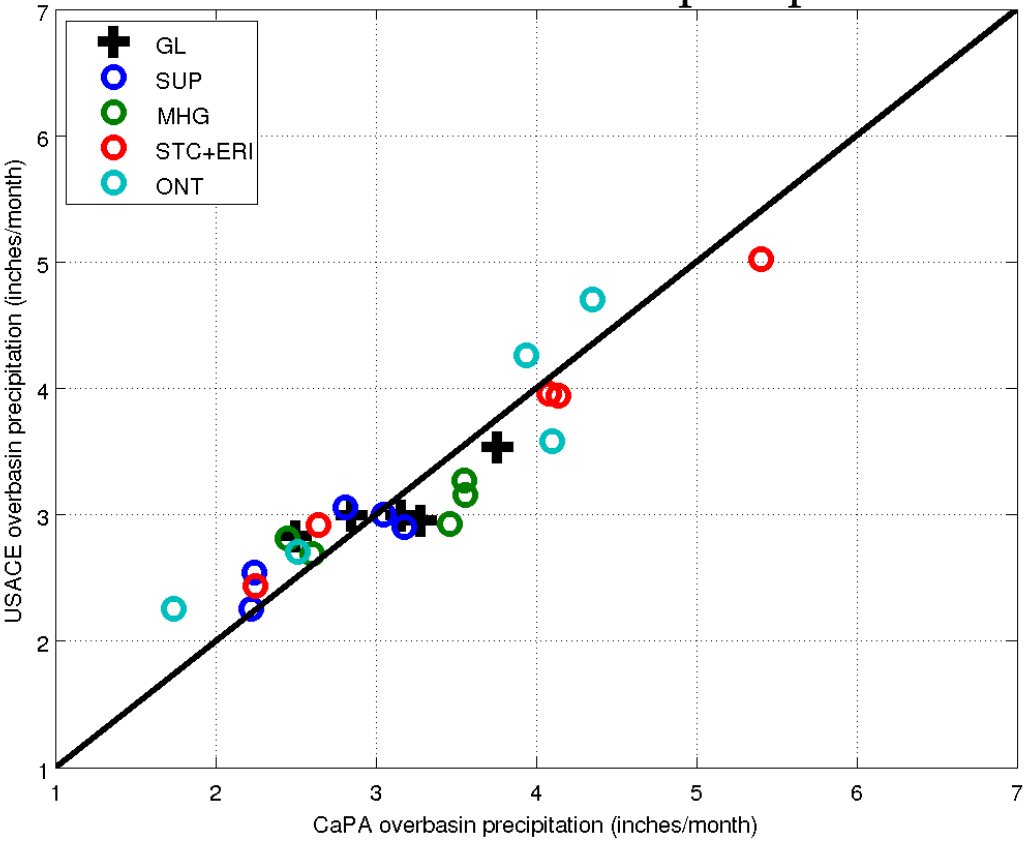
CPC



Ratio of CaPA to USACE NEW overbasin average



CaPA vs USACE NEW overbasin precipitation



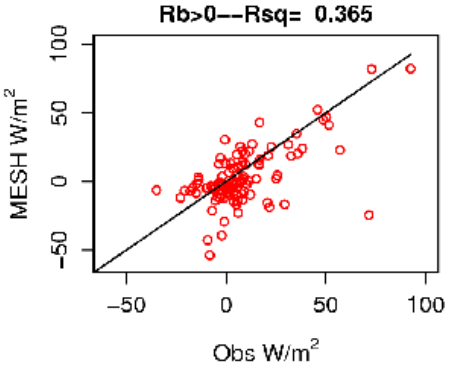
Verification of Overlake Evaporation

Observations courtesy of Chris Spence, NWRI

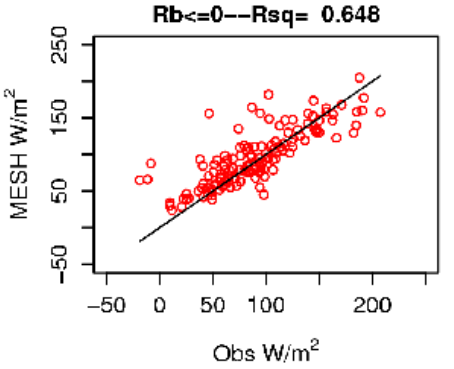
Eddy-correlation system

Verification of daily mean flux (June 2008 – January 2009)

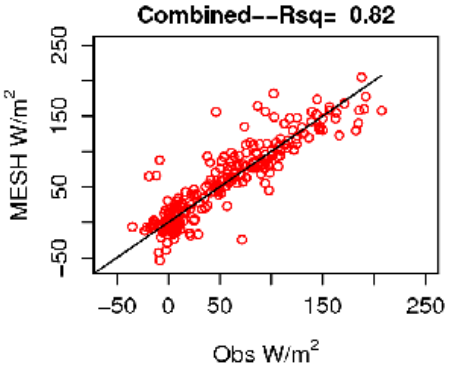
Stable conditions



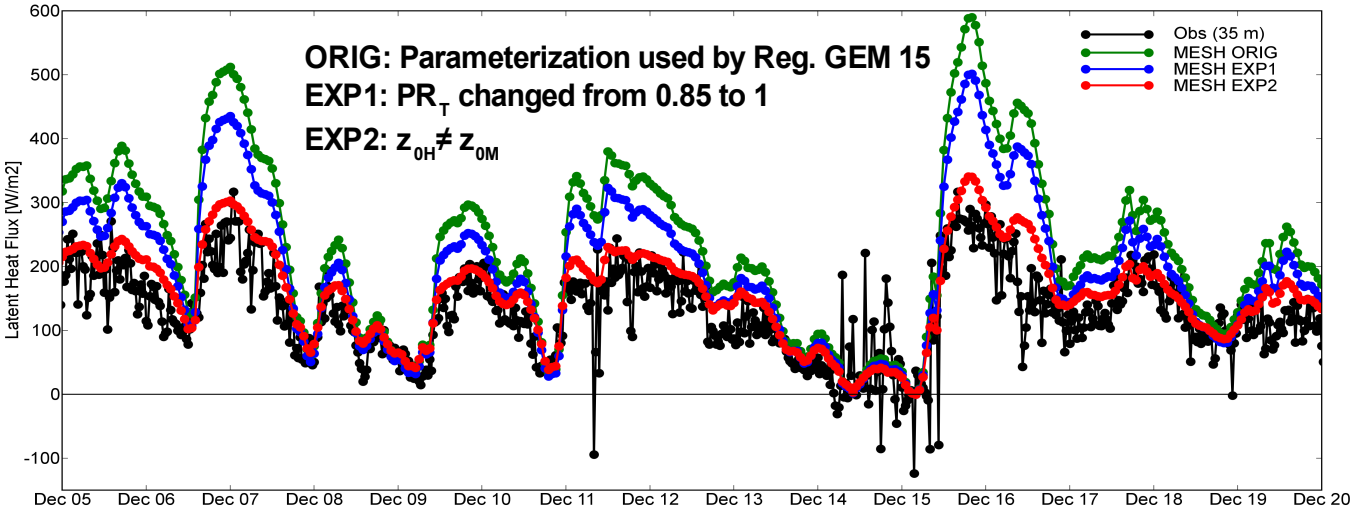
Unstable conditions



All cases



Verification of half-hourly fluxes for December 2008:

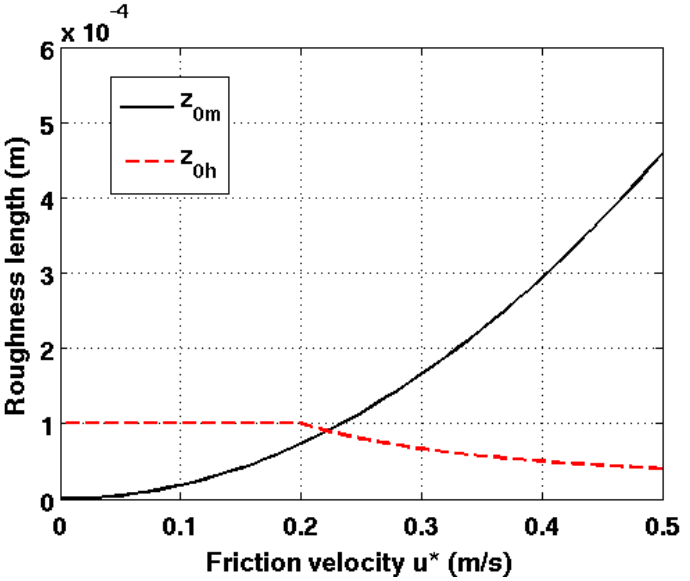


Modifying the Surface Turbulent Flux Parameterization over Water

Momentum roughness length: $z_{0m} = 0.018 \frac{u_f^2}{g}$

Scalar roughness length: $z_{0h} = min(\frac{0.2}{u_f}, 1) \times 10^{-4}$

u_f = friction velocity, g = gravitational acceleration

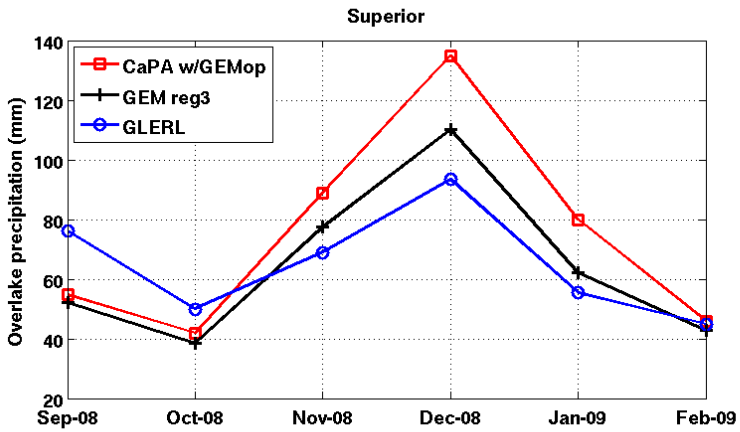


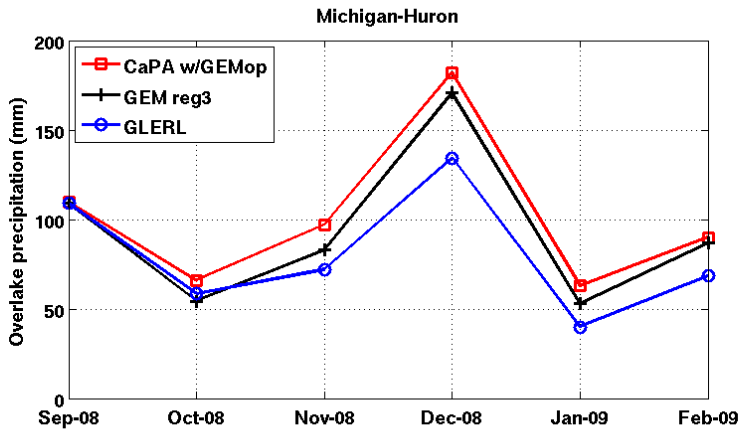
Surface Flux Parameterization	Z_{0m}	Z_{0h}	Prandtl number
Original	**Eq. 1**	**Eq. 1**	**0.85**
EXP1	**Eq. 1**	**Eq. 1**	**1**
EXP2 (final)	**Eq. 1**	**Eq. 2**	**1**

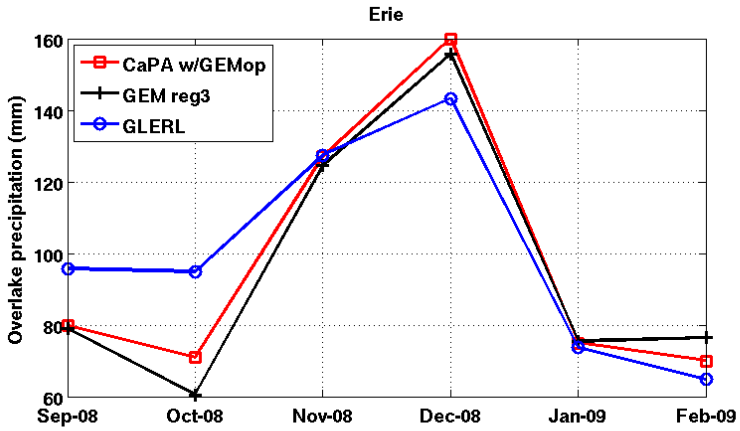
$Pr_T = \epsilon_m / \epsilon_h$

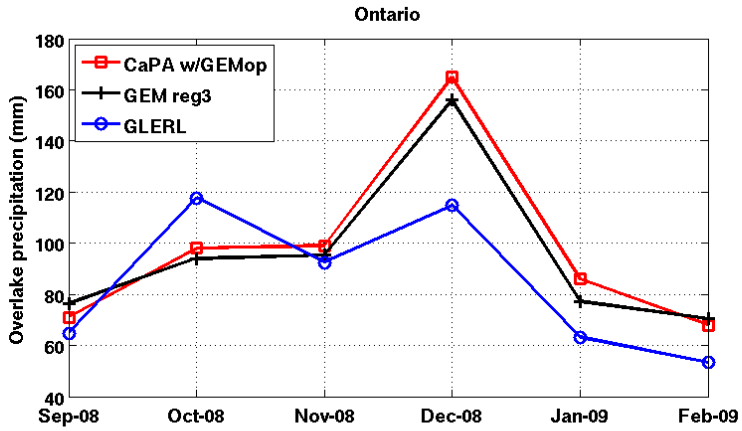
Impact of improvements to GEM evaporation on precipitation

- Reduction in evaporation brings reduction in precipitation
- Still quite different from GLERL land-based estimate!
- These changes should make it into next op. version of GEM





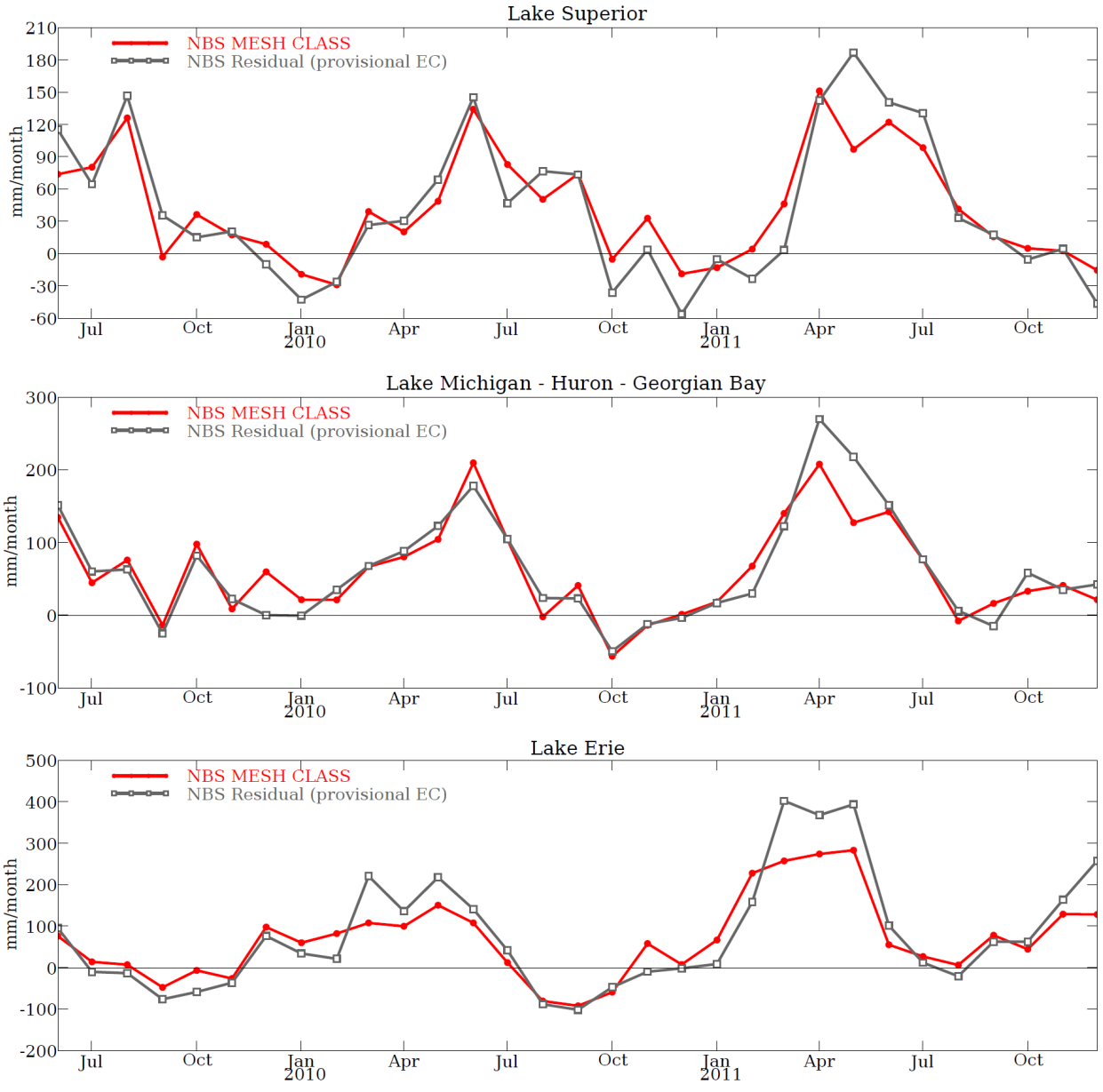




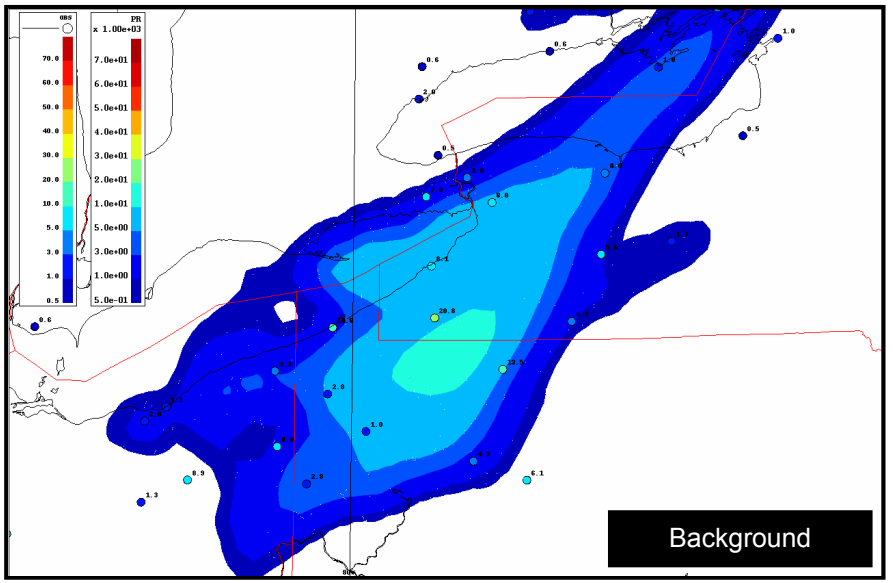
Hydrological prediction of Net Basin Supply to the Great Lakes using CaPA

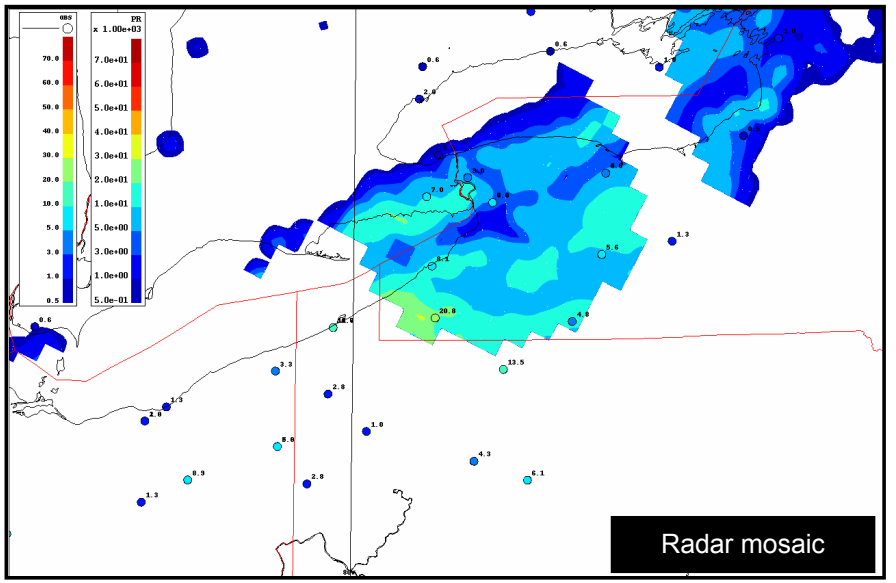
MESH model

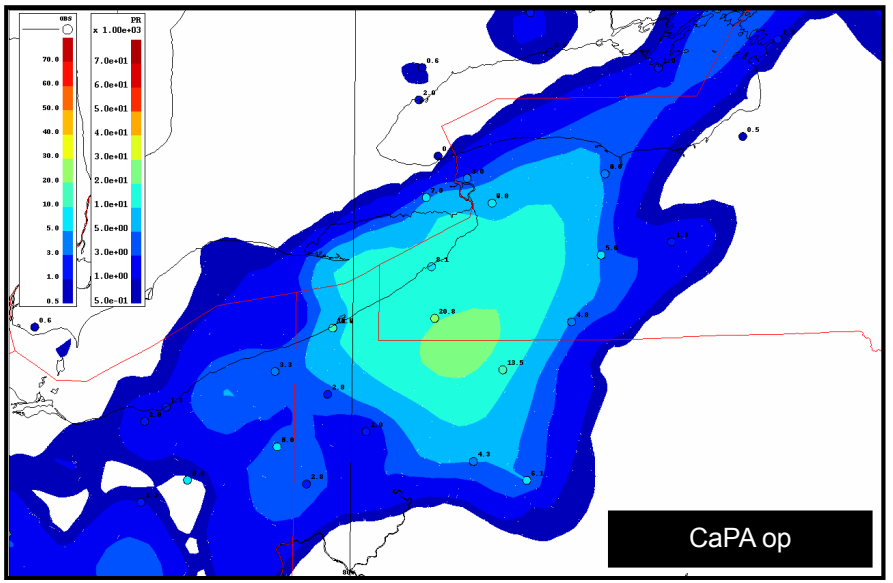
- CLASS land-surface scheme
- WATROUTE routing model
- GEM RDPS forcing, 6h-12h lead time
  - except for precip for which CaPA is used

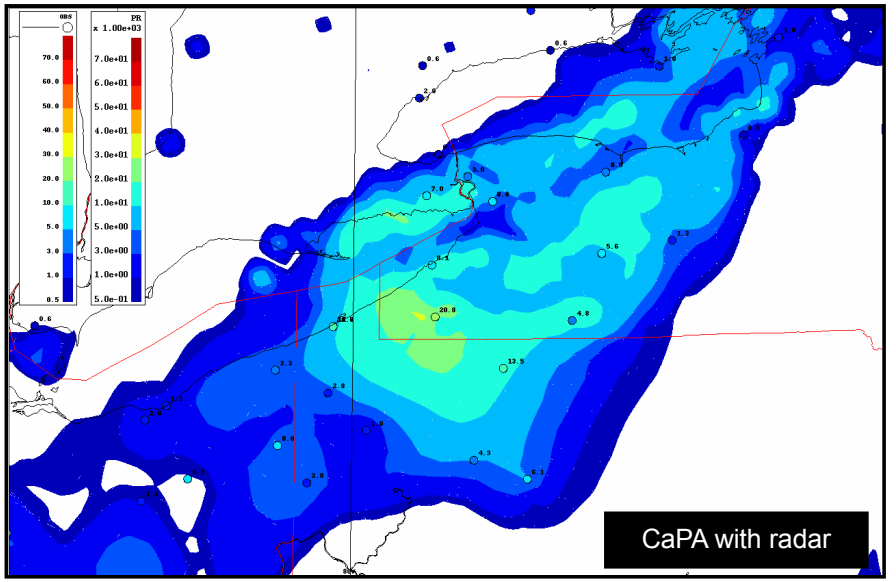


Assimilation of radar QPE, 2011-08-21 12 UTC (6h accumulation)





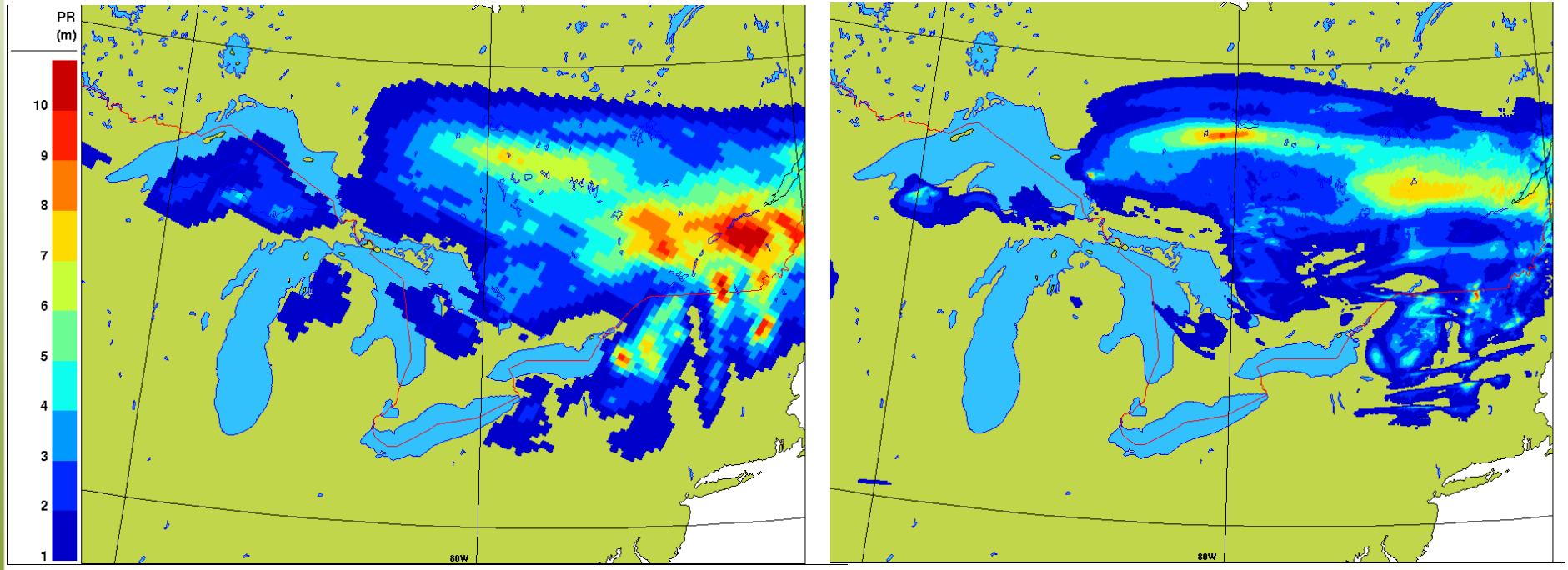




Experimental GEM-LAM 2.5 km window: Towards a hourly, 2.5km version of CaPA

GEM 15km RDPS (CaPA background)

GEM-LAM east 2.5km HRDPS



24h forecast of cumulative precipitation
valid 2012-02-28 12 UTC
issued 2012-02-27 12 UTC

CaPA on the web

- Operational web site: images

  http://www.weather.gc.ca/analysis/

- GRIB 2 files on the datamart

  http://www.weatheroffice.gc.ca/grib/grib2_RDPA_ps15km_f.html

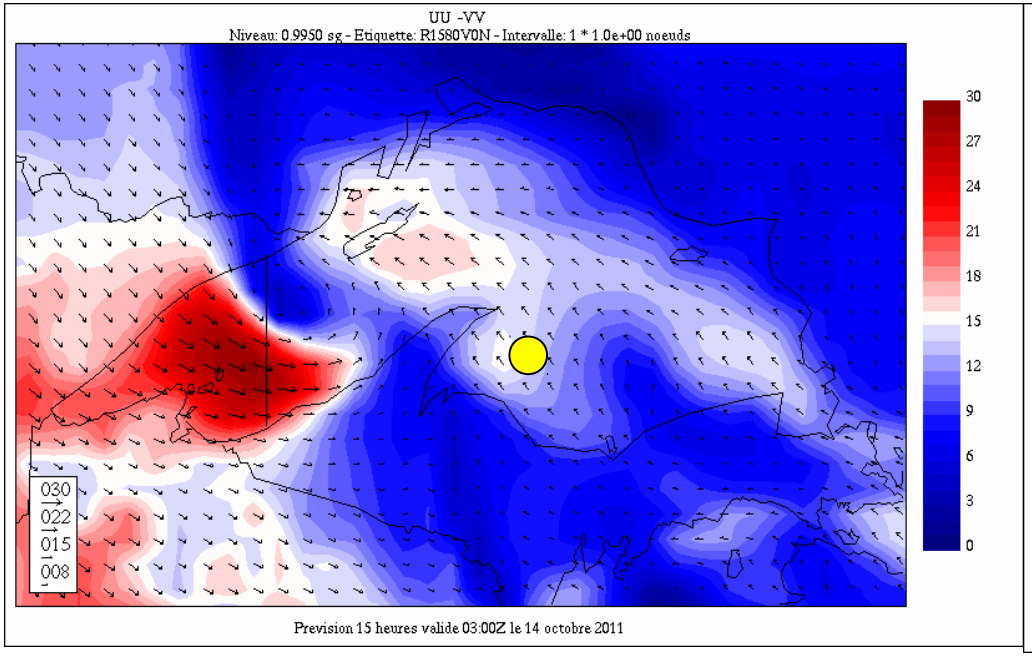
- Experimental web site

  http://loki.qc.ec.gc.ca/DAI/CaPA

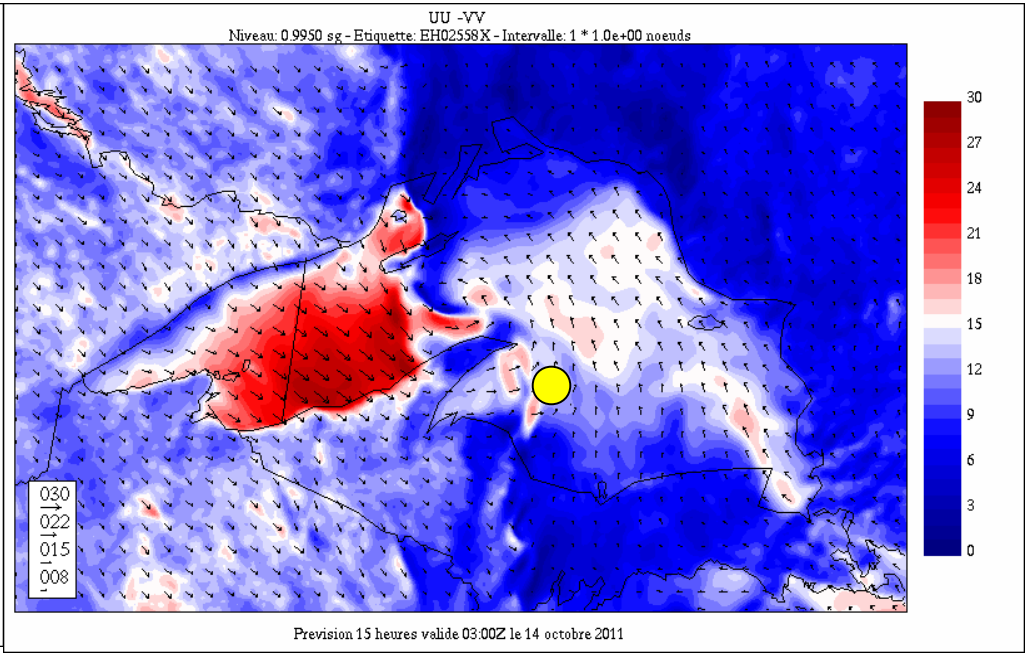
SAINT-JEAN-SUR-RICHELIEU

Wind field as seen by 15km and 2.5km GEM model
as the frontal system is passing over Stannard Rock

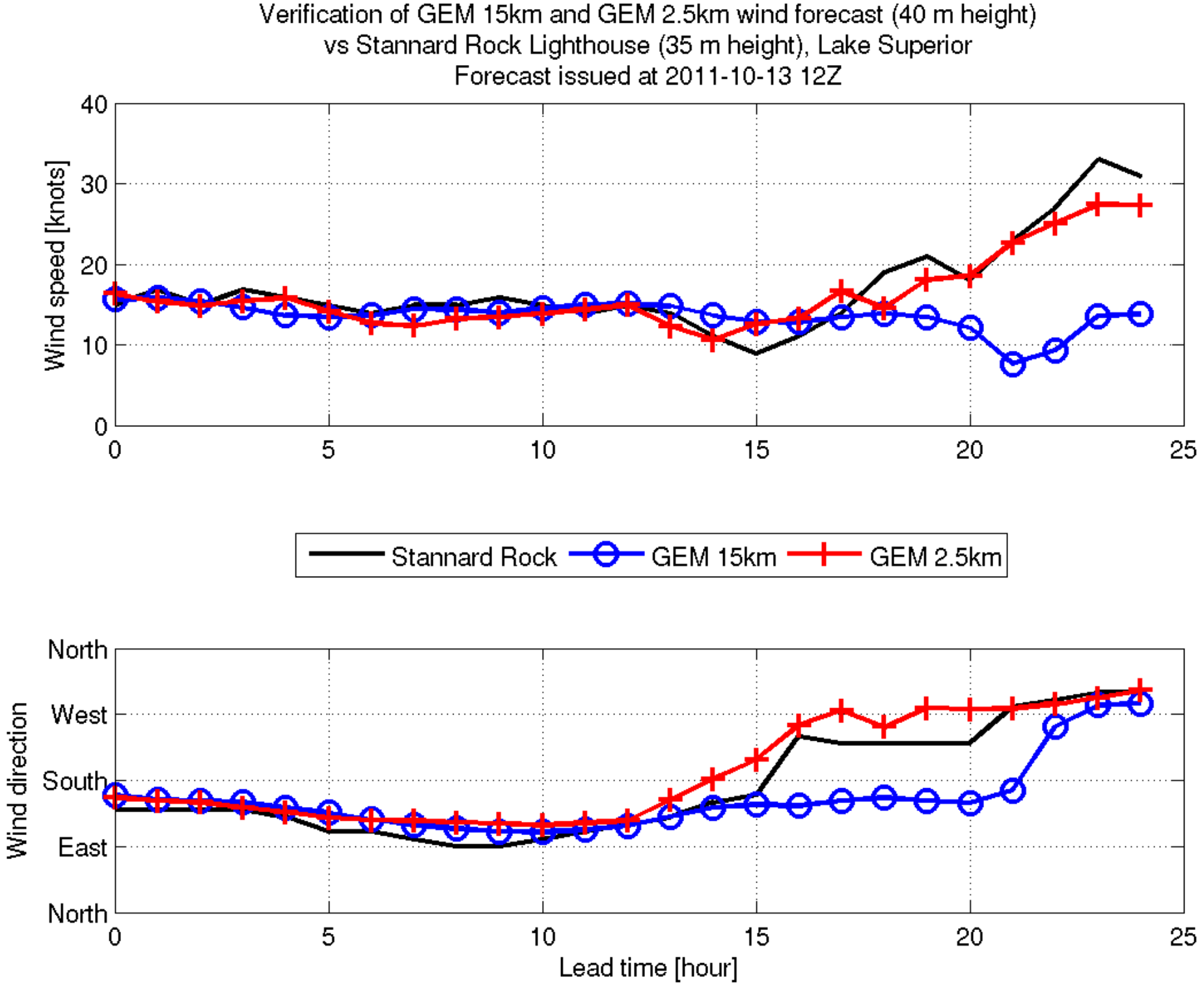
GEM 15 km



GEM 2.5 km

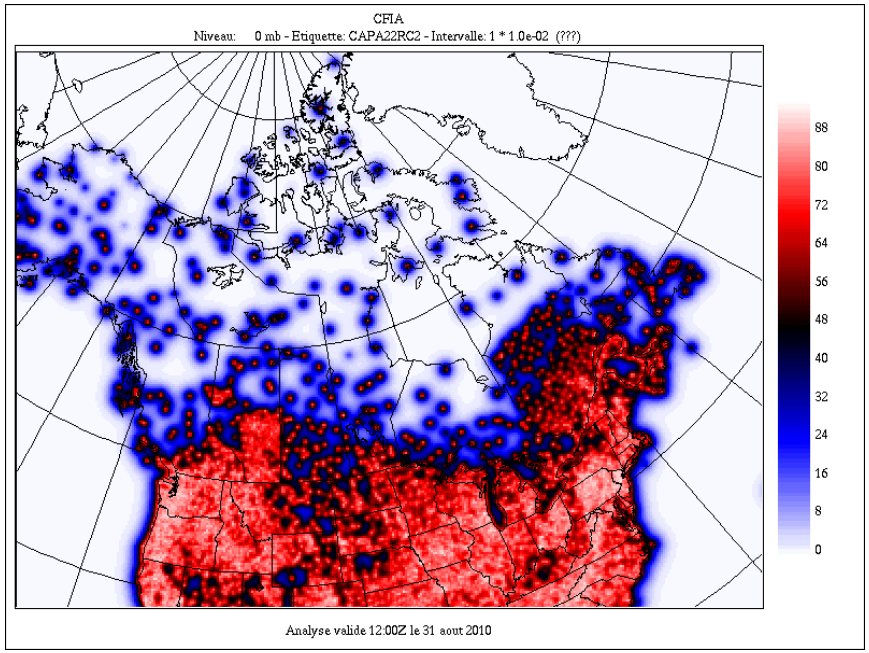


Forecast issued at 12 UTC, Oct. 13, 2011
Valid at 03 UTC, Oct. 14, 2011

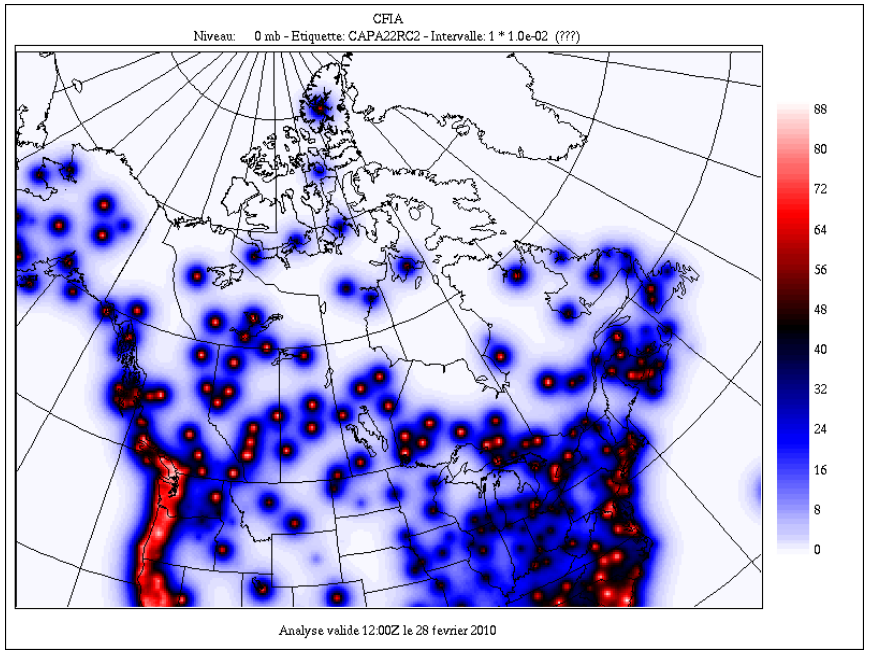

Verification of GEM 15km and GEM 2.5km wind forecast (40 m height)
vs Stannard Rock Lighthouse (35 m height), Lake Superior
Forecast issued at 2011-10-13 12Z
Wind speed [knots]
0
10
20
30
40
0
5
10
15
20
25
Stannard Rock
GEM 15km
GEM 2.5km
Wind direction
North
West
South
East
North
Lead time [hour]

Mean value of confidence index (24h analysis)

JJA 2010



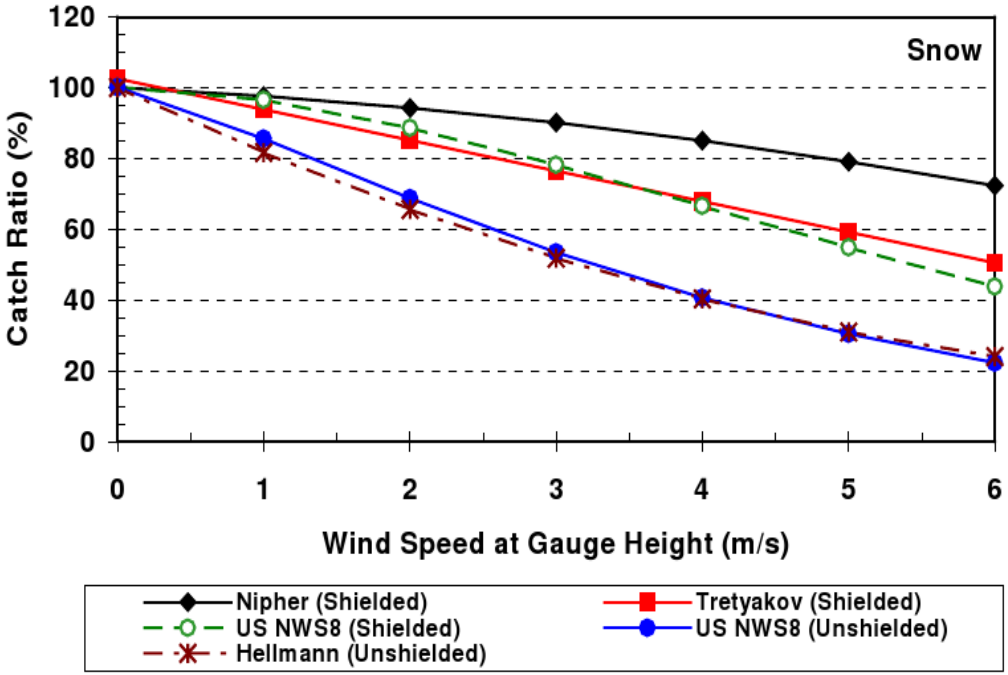
DJF 2010



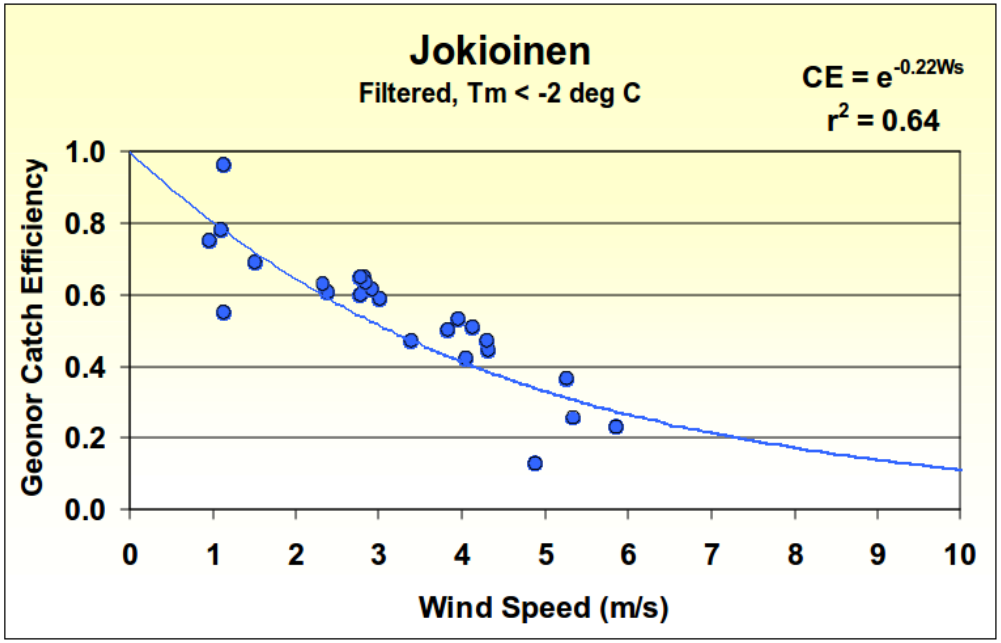
Catch efficiency of various gauges vs WMO secondary ref. (DFIR)

- For cold snow (Tmax < -2C), things are worse for wet snow!

Manned gauges (WMO 1989)



Geonor gauge with Alter shield



Courtesy of Craig Smith

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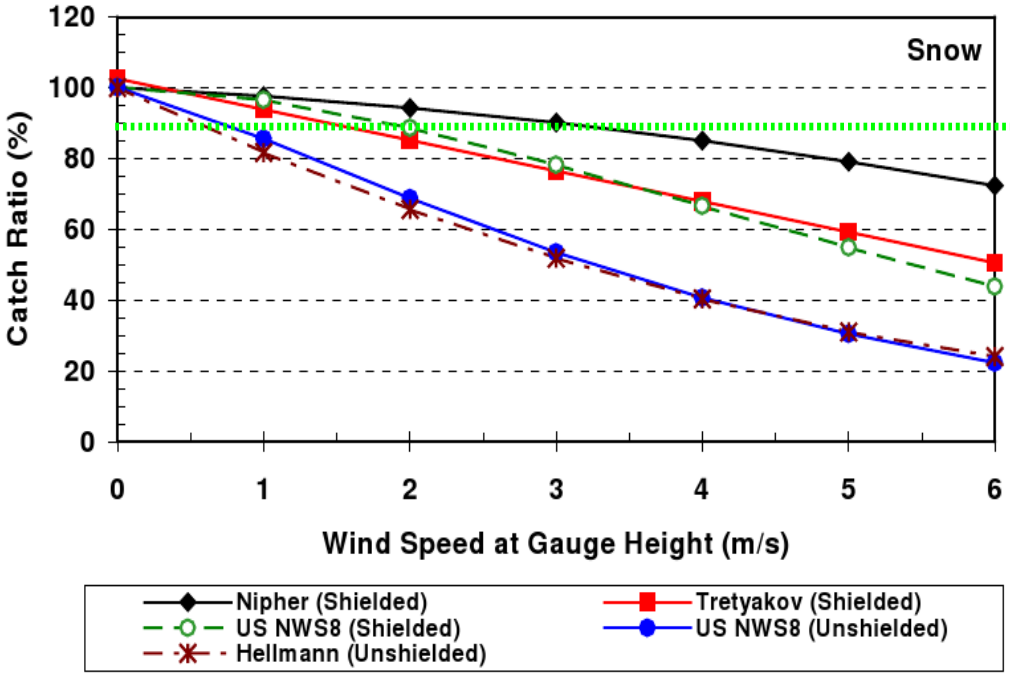
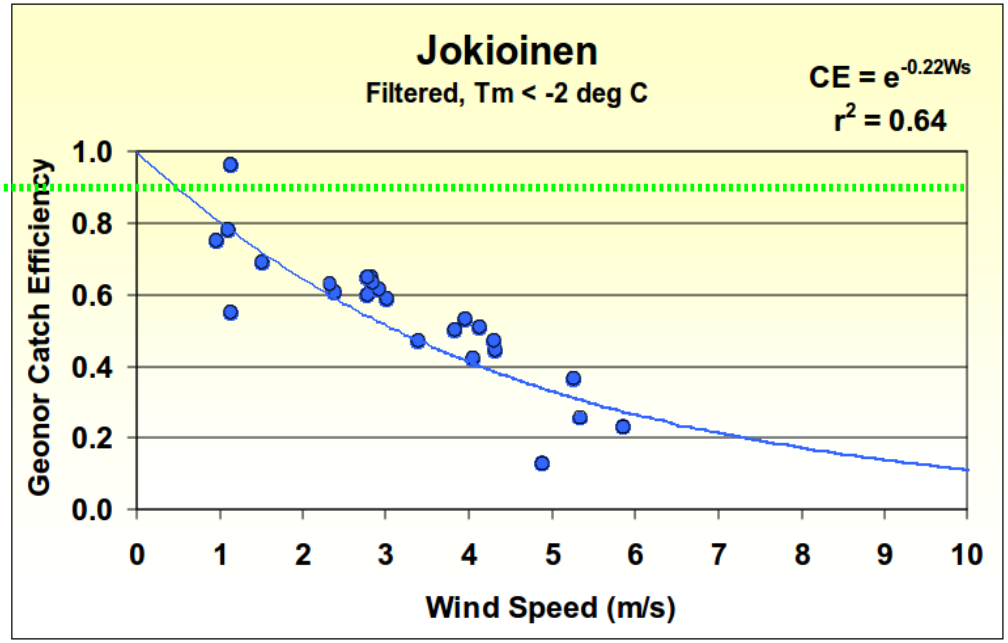


Geonor gauge with Alter shield



Courtesy of Craig Smith

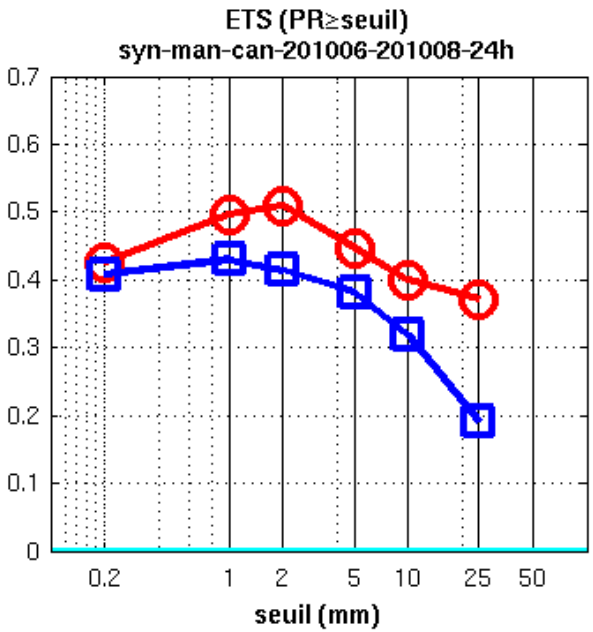
Strategy for assimilation of solid precipitation observations

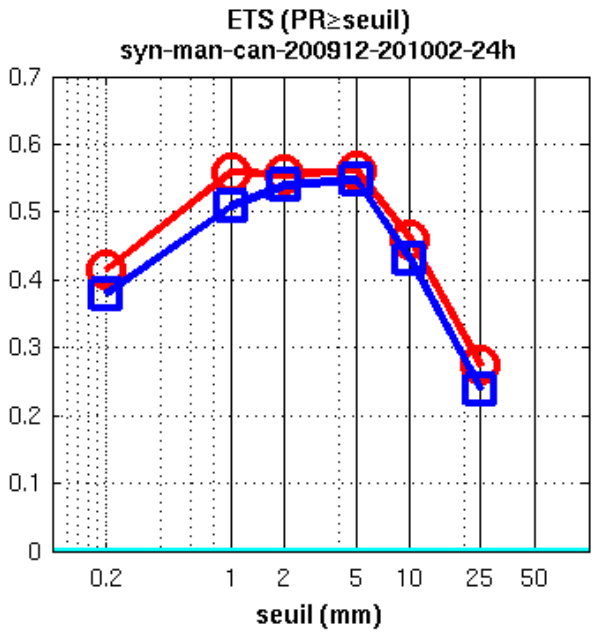
- If not available, estimate mean wind speed at gauge height from 10m wind speed assuming log profile (UV_{2m})
- Accept obs. stations only if UV_{2m} less or equal to:
  - 3 m/s for Canadian manned synoptic gauges
  - 2 m/s for US manned synoptic gauges
  - 0 m/s for automatic gauges
- Despite being very strict, this strategy was shown to improve bias and ETS of analysis vs assimilating all obs.
- Bias-correction procedure would be preferable (currently under development)
  - Requires additional data (temperature, wind speed) and metadata not currently available at all stations (eg wind shield type)

JJA 2010

DJF 2010

24h vs CMAN



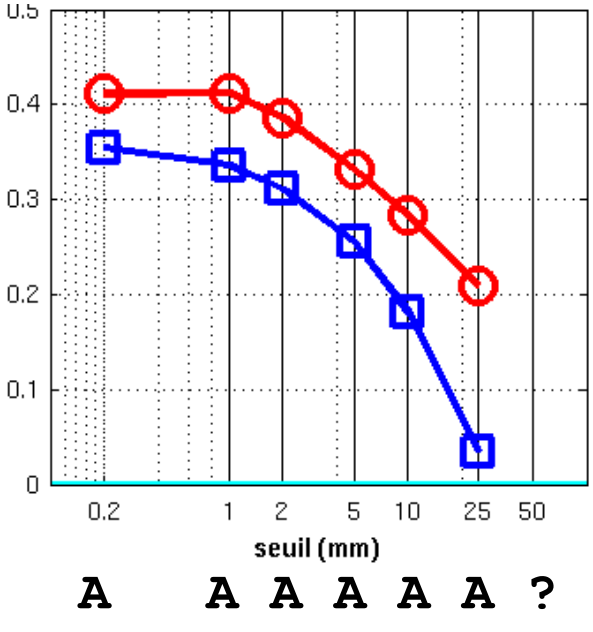


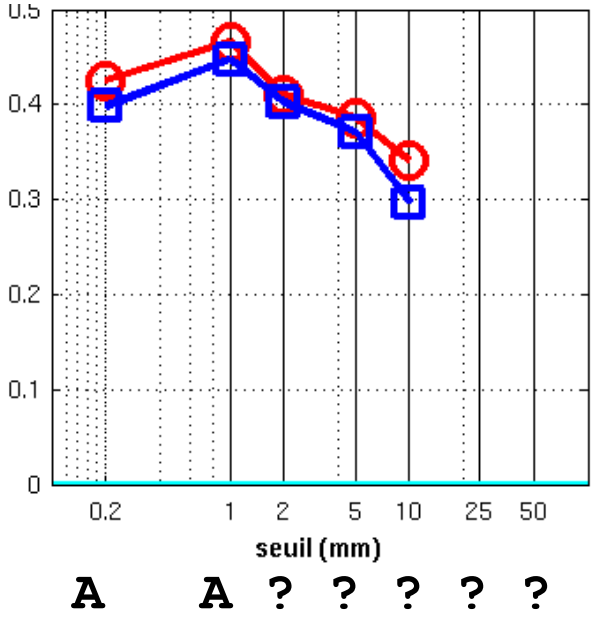
24h vs CMAN

A A A A A A ?

A A A ? ? ? ?

6h vs CMAN





6h vs CMAN

A A A A A A ?

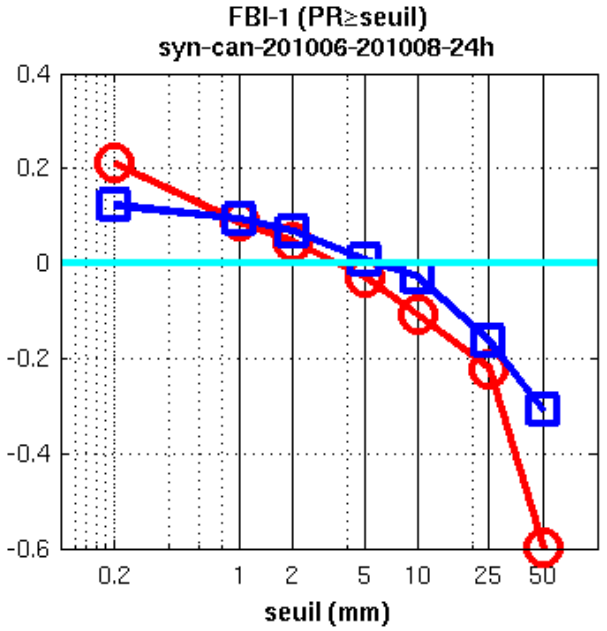
A A ? ? ? ? ?

Equitable Threat Score (ETS)

JJA 2010

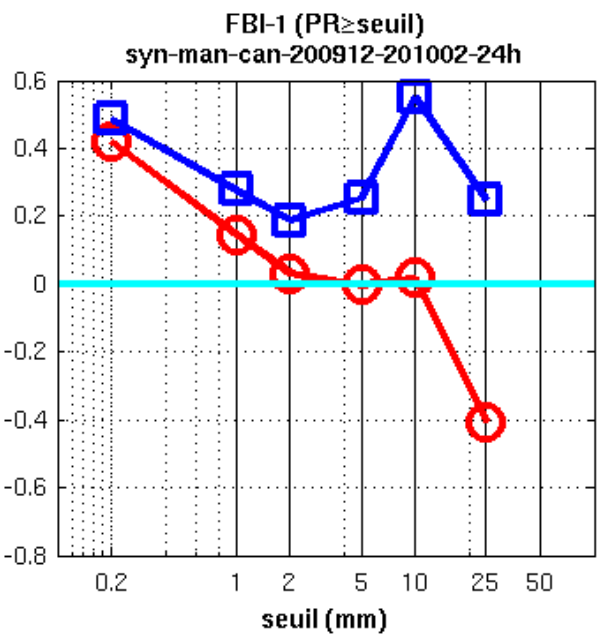
DJF 2010

24h vs CAN



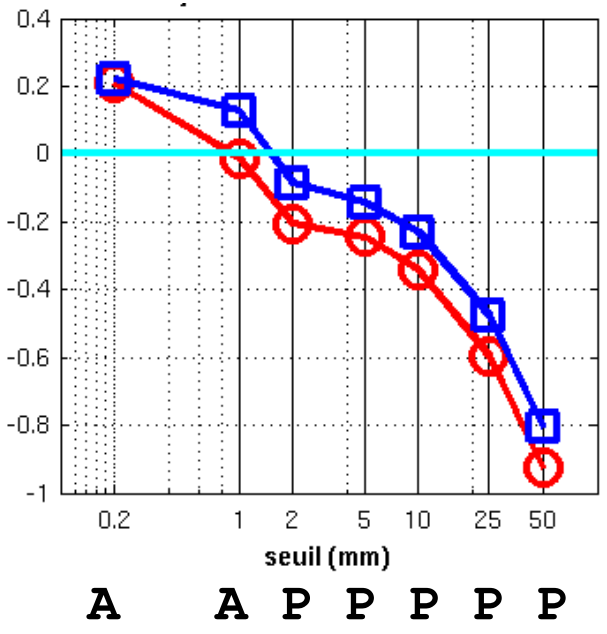
P ? A ? P P P

24h vs CMAN



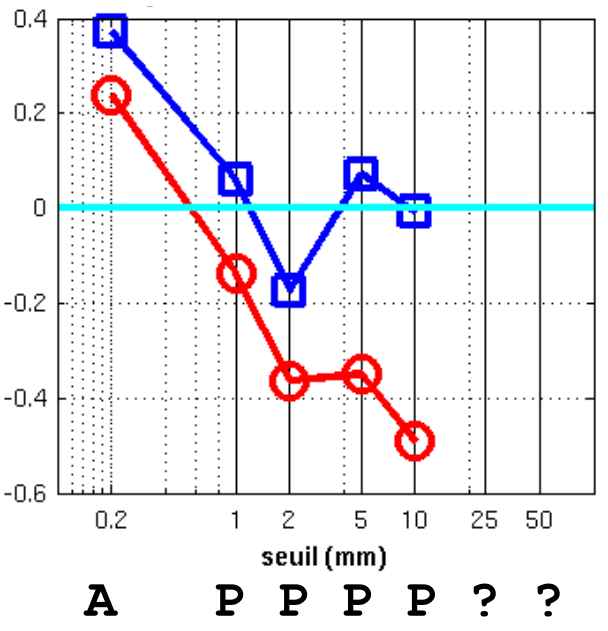
A A A A A ? ?

6h vs CAN



A A P P P P P

6h vs CMAN

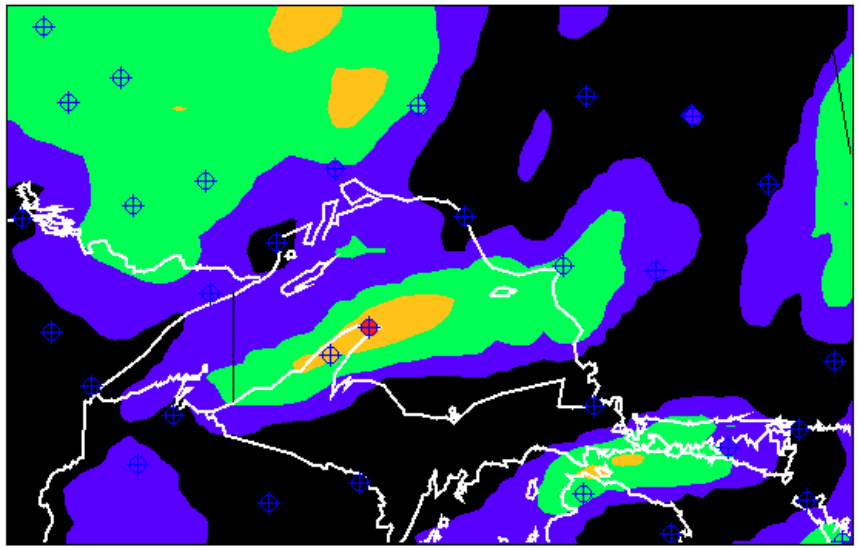


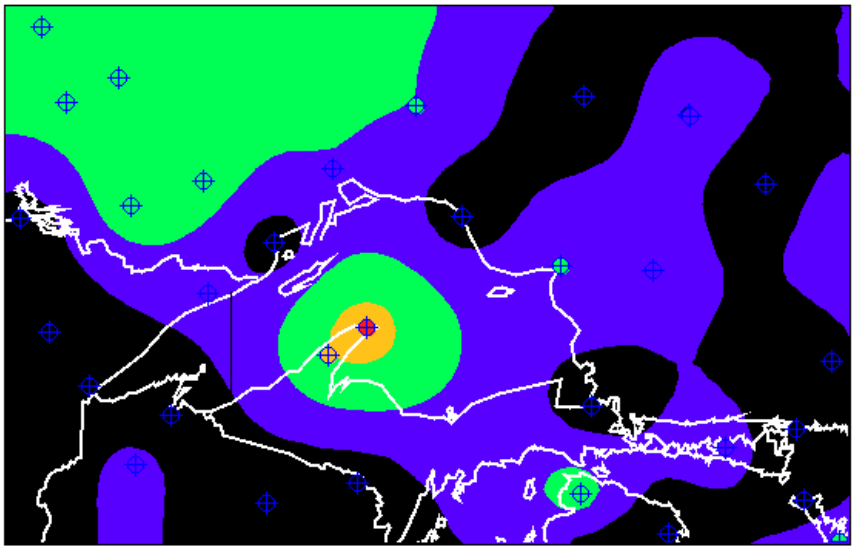
A P P P P ? ?

Frequency Bias Indicator (FBI) -1

CaPA vs Ordinary Kriging over Lake Superior

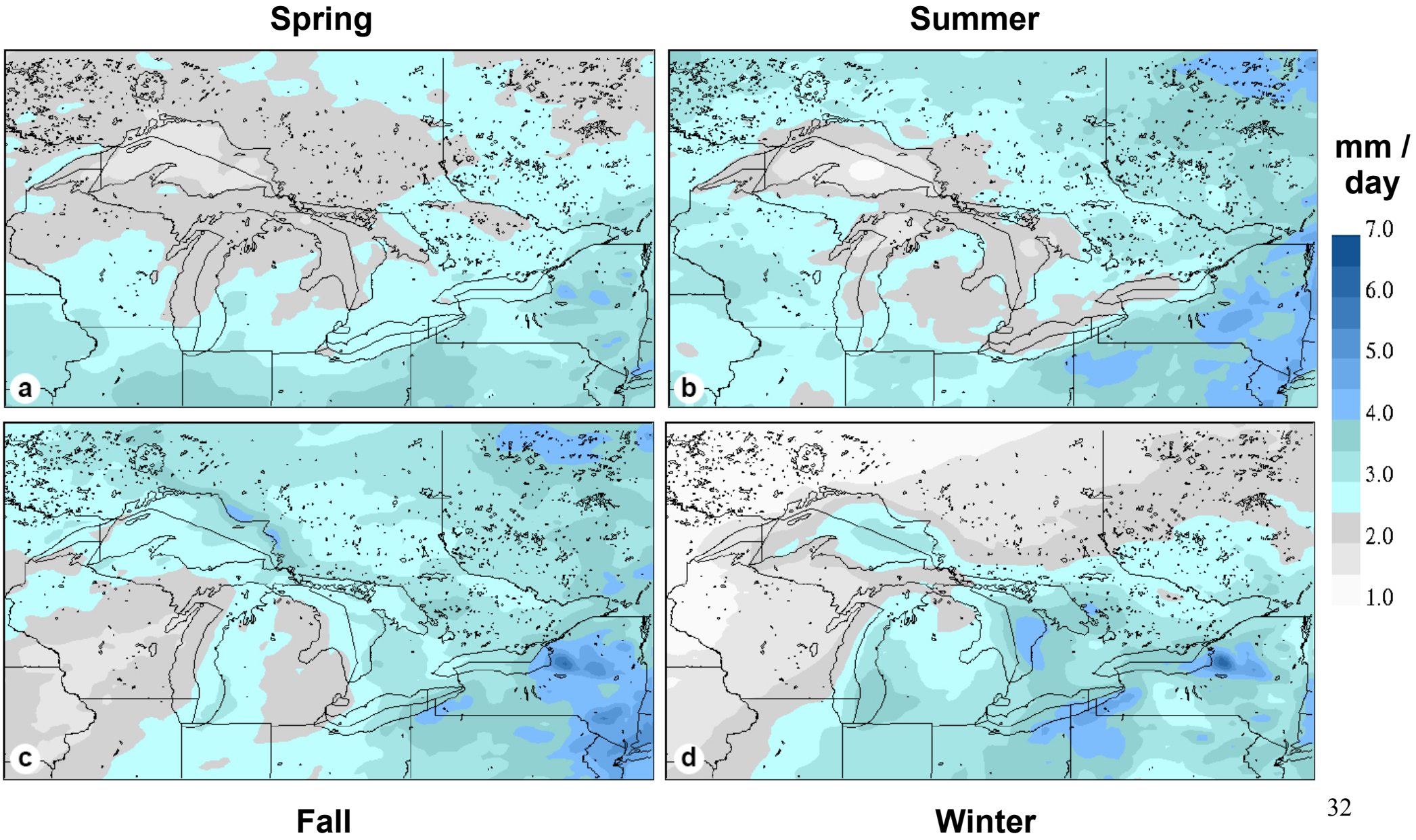
- Residual kriging: CaPA
- Ordinary kriging



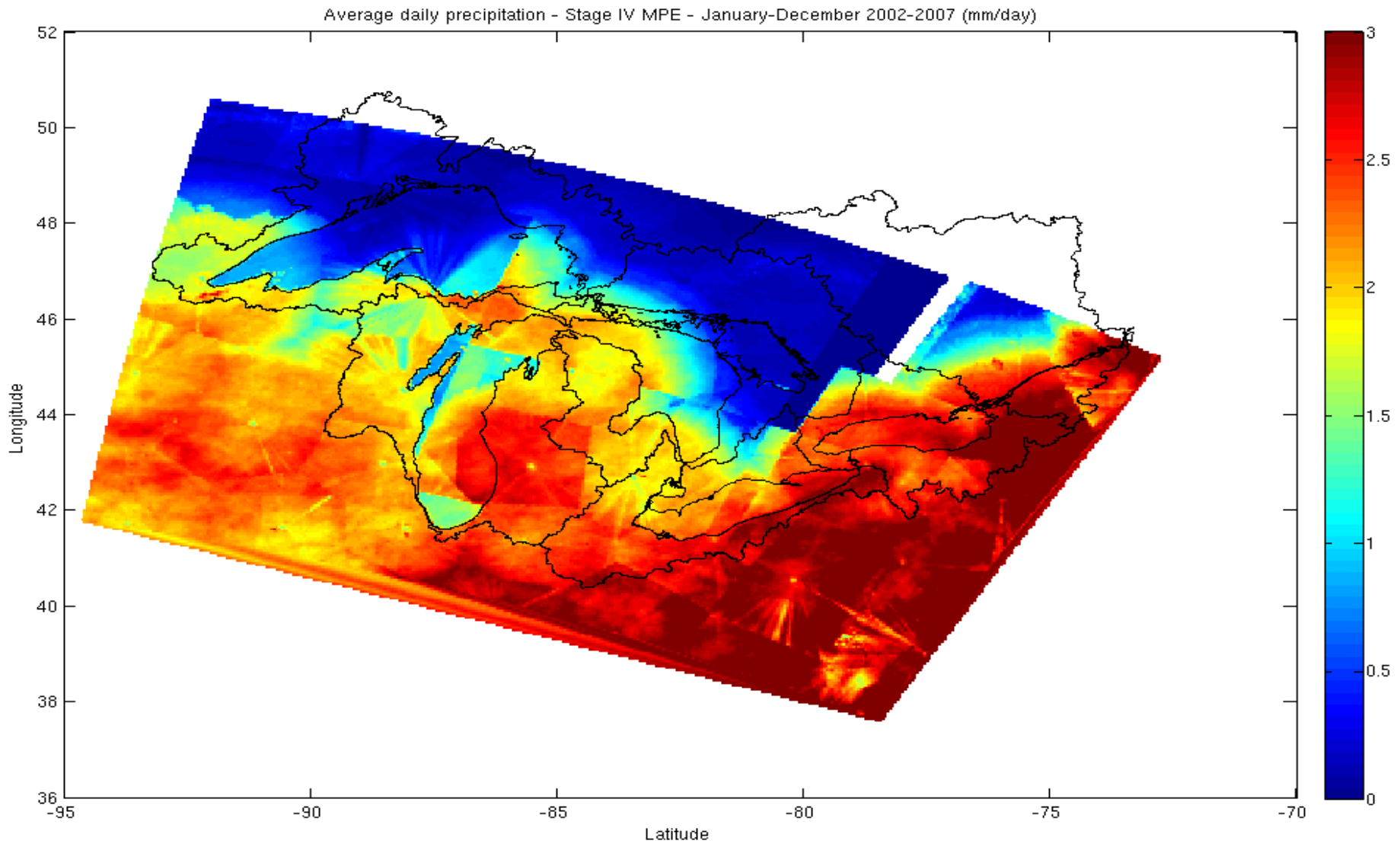


6h accumulation valid on 2006-10-13 at 0Z

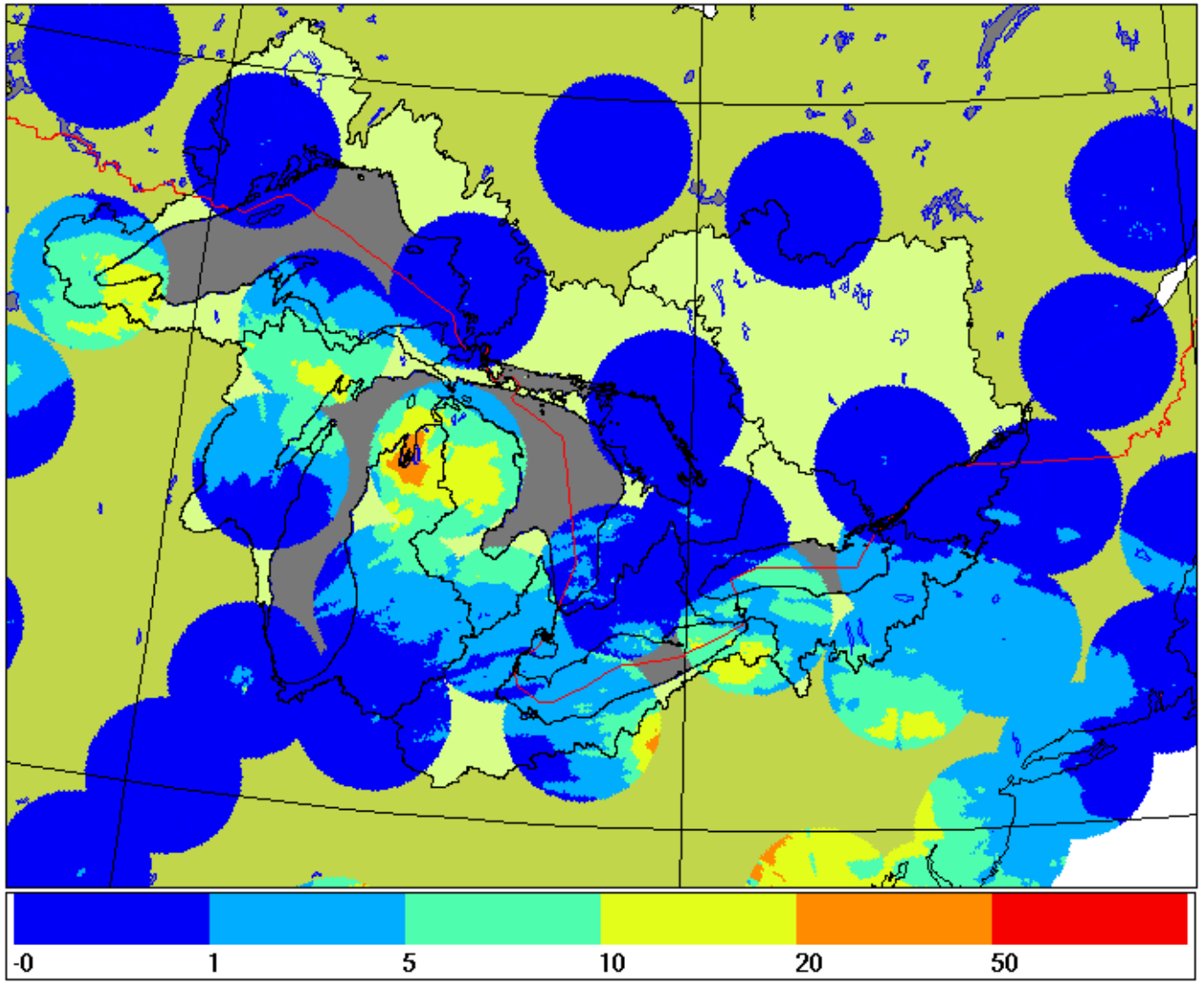
5-year average (June 2004 - May 2009) of GEM precip. with new surface roughness parameterization



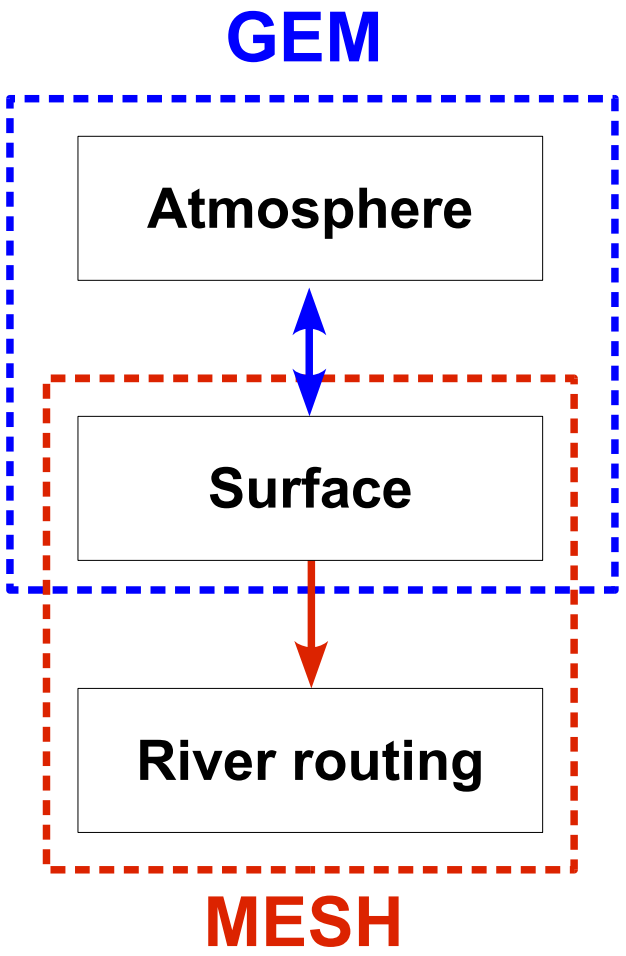
Average daily precipitation Stage IV MPE 2002-2007



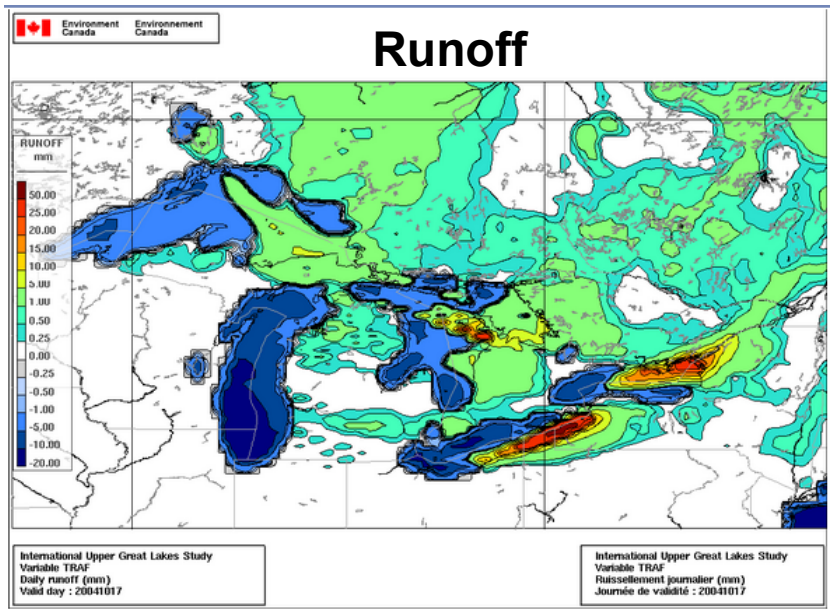
Radar mosaic for the Great Lakes 120 km radius, 2012-02-29 12Z-18Z

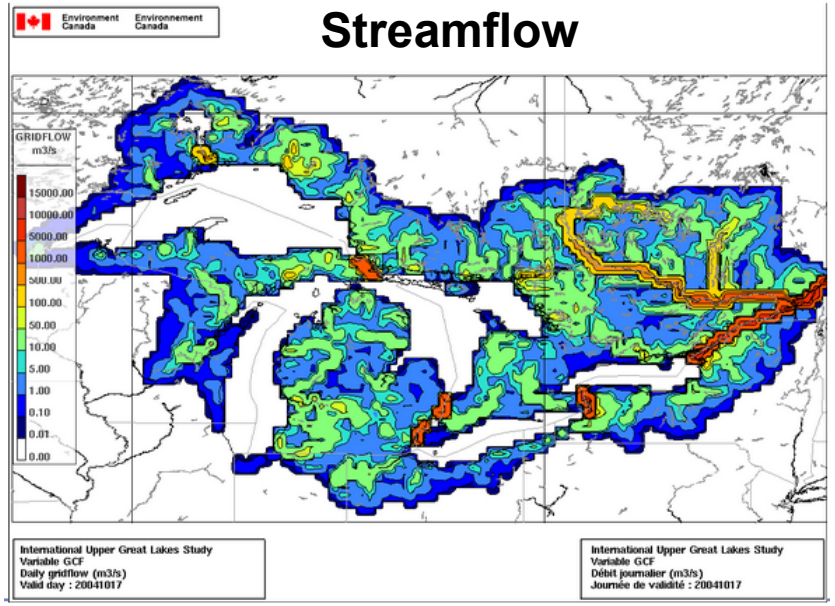


Hydrological prediction of Net Basin Supply to the Great Lakes

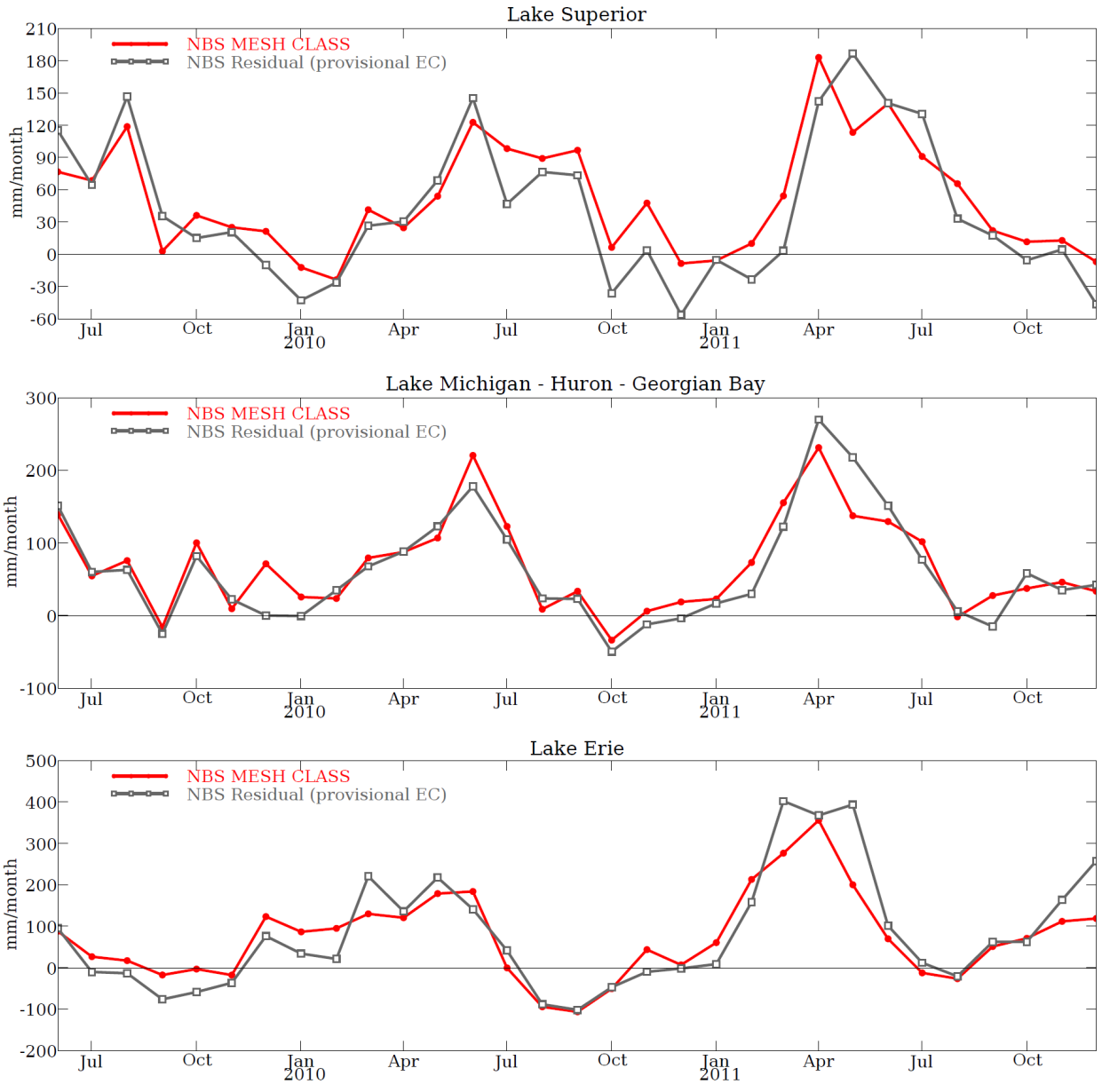


Horizontal resolution: 15 km





Hydrological prediction of Net Basin Supply to the Great Lakes using GEM

MESH model

- CLASS land-surface scheme
- WATROUTE routing model
- GEM RDPS forcing, 6h-12h lead time